THE FOUNDRY

Vol. 43, No. 12 Cleveland, Ohio, December, 1915 *Whole No. 280*

How to Mold Large Centrifugal Pump Casings

The Difficulties of Molding and Casting This Class of Work Were Successfully Overcome by Careful Foundry Practice—Proper Handling of Cores

INTERESTING foundry problems frequently are encountered in molding and casting large centrifugal pump castings. Although the castings are bulky and heavy, the metal sections are comparatively limited and great care must be taken in setting and anchoring the cores to prevent displacement, the difficulties being increased by the size of the cores. Furthermore, the foundryman usually is obliged to use standard flasks and equipment, the margin of profit not permitting a heavy investment in special rigging. It is the purpose of this article to point out how some of the obstacles met with in this class of work were overcome in making the castings for four 72-inch, 1,000,000-gallon, twin centrifugal pumps at the plant of the McIntosh & Seymour Corporation, Auburn, N. Y. The pumps were designed for work on a drainage proposition in the south, the average head of water being 12 feet.

The casing for each pump consists of eight separate castings. One of the finished casings is shown in Fig. 1 assembled on a boring mill. As this illustration indicates, the upper part *A* is cast separate from the lower portion *B*, the two parts being bolted together in the middle. The part *A* is comparatively simple, the lower part being complicated by the inlet and outlet passages. A detailed internal view of this part of the casing is shown in Fig. 2, which indicates how the twin castings are bolted together. The twin cover pieces, *A*, Fig. 1, are bolted to the finished flange shown in the foreground of Fig. 2.

The lower part *B* was molded in a pit using a cheek and a cope, the cover pieces *A* being molded separately in large cast iron flasks. Completely formed, built-on, hollow wooden patterns were made for both portions of the casing. The patterns were split through the axis of the pump runner.

The pit in which the lower piece *B* was molded was 13 feet square and four feet deep. It is shown in Fig. 3 with the mold in a partially finished condition. The cheek, which fits over the pit portion of the mold, flush with the floor level, was 30 inches in depth. The cope, which served simply as a cover was 12 inches in depth. Cast iron flasks 13 feet square were used for the cheek and cope molds. The metal in the casting has an average thickness of one inch. The casting for the lower part *B*, Fig. 1, weighs 15,000 pounds, the cover piece *A* weighing 6,500 pounds.

As indicated in Fig. 3, the flanges, with which the two symmetrical portions of the completed casing are bolted together, were made in dry sand cores

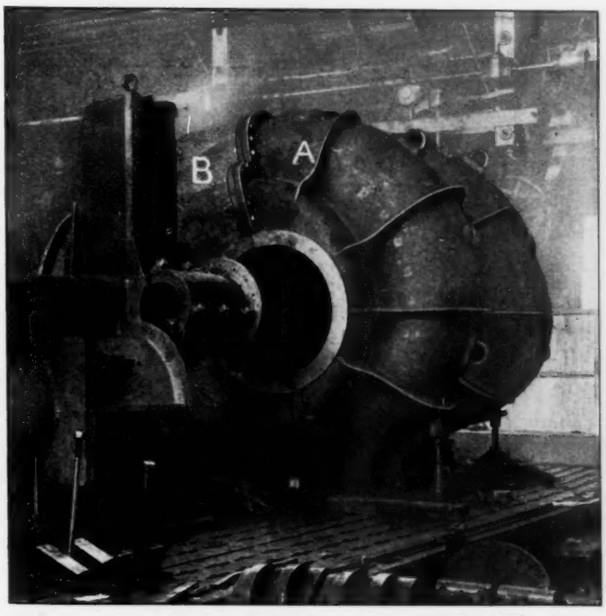


FIG. 1—PUMP CASINGS IN MACHINE SHOP

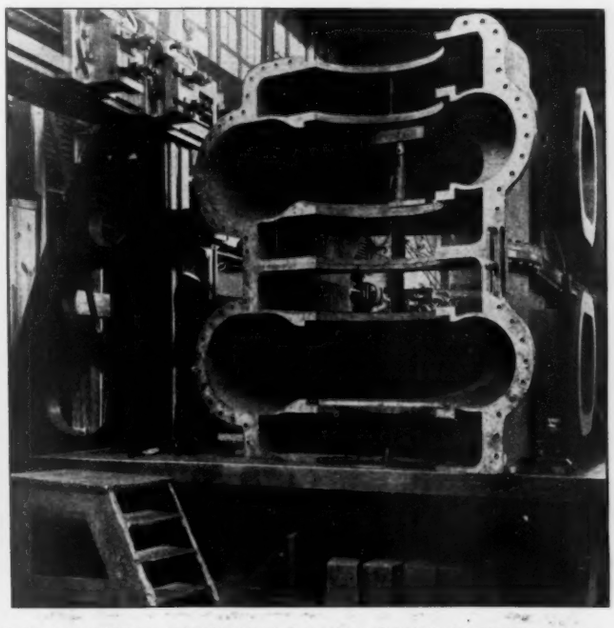


FIG. 2—LOWER PORTION OF PUMP BEING FINISHED ON A PLANER—THIS IS THE PART MARKED *B* IN FIG. 1

FIG. 3—PIT MOLD FOR PART *B* SHOWN IN FIGS. 1 AND 2

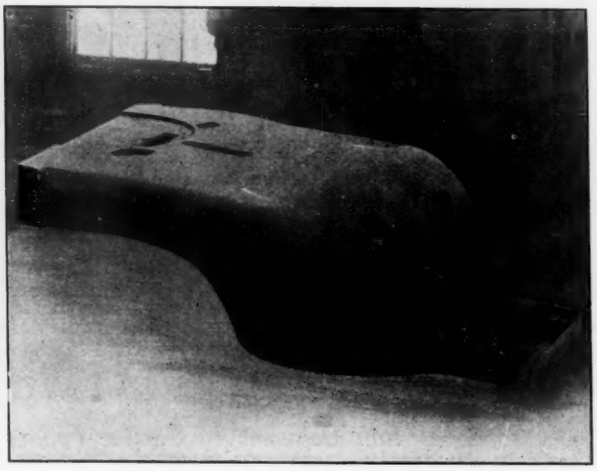


FIG. 4—INLET PASSAGE CORE READY TO BE SET IN MOLD

which were set in the pit after the pattern was withdrawn.

The snail core forming the runner passage was made on cast iron arbors, two inches square, reinforced by heavy rods as shown in the background of Fig. 5. The interior of the core was vented with coke. The water passages which surround the lower half of the runner were formed by large dry sand cores, one of which is shown in Fig. 4. In closing the pit mold, the bottom water passage and flange cores were set first, followed by the snail core, after which the upper water passage core was dropped into position.

Three molders were employed on the job, and the cores were made by two men. An average of one casting a week was turned out. The metal was poured through two ¾ by 4-inch gates connected to the flanges. Six risers 3½ inches in diameter were provided; they were attached to the upper portion of the flanges and other high parts on the castings. The metal was fed through a green sand pouring basin.

The cover pieces *A*, Fig. 1, were made in a 7 by 10-foot cast iron flask, the drag being 3½ feet and the cope 4 feet in depth. Only one large core was required to form the runner chamber. The molds were oven-dried before they were poured.

A close-grained, comparatively low silicon iron was employed. The metal analyzed as follows: Silicon 1.66 per cent; sulphur 0.08 per cent; phosphorus 0.575 per cent; manganese 0.41 per cent; graphitic carbon 3.03 per cent; combined carbon 0.45 per cent. This metal was obtained from a mixture containing 47½ per cent No. 2 plain northern foundry pig iron; 5 per cent No. 3 Susquehanna pig; 2½ per cent of 10 per cent silicon pig; 7½ per cent old car wheels; 35 per cent returned foundry scrap and 2½ per cent selected steel scrap. Seventy-two hour foundry coke was used, the melting ratio being approximately one to nine.

Products Described

A catalog edition of "The Merry Molder", the house organ of the Osborn Mfg. Co., Cleveland, containing 30 pages, illustrates and describes briefly the different types of machines built by this company. These include rock-over drop-draft, drop-plate stripping plate machines, hand squeezers, roll-over hand squeezers, power squeezers, jolt-ramming machines, combination stripping plate and roll-over machines, electrically-driven jolt-ramming machines, special machines of various types, as well as pneumatic vibrators and other equipment for molding machine operations.

FIG. 5—SNAIL CORE WITH CORE-BOX IN THE BACKGROUND

Pennsylvania's Control of Foundry Operations

A Summary of the New Regulations Adopted by That Commonwealth Governing the Operations of Casting Plants—Similar to New York State Rules

REGULATIONS governing the control of foundry operations in the state of Pennsylvania, known as "Safety Standards", and compiled by the State Industrial Board, became effective Nov. 1. In many respects the provisions are similar to those adopted by the New York Industrial Commission, although many of the stringent requirements enforced by the latter are lacking. In Ohio, rules governing the equipment and operation of foundries are being drawn, and it is probable that in other states in which the foundry industry ranks high among the metal-working trades similar codes soon will be adopted. The standards to which Pennsylvania foundries must comply follow:

Definitions

An iron or steel foundry shall mean a place where iron or steel or both metals are melted and poured into molds in the making of castings, together with all cleaning, coremaking, drying, wash rooms and toilet rooms, used in connection therewith.

The term *entrance* as used in these regulations, shall mean main doorways opening directly to the outer air.

The term *gangway* as used in these regulations, shall mean well defined passageways dividing the working floor of foundries, but not the spaces between molds. Spaces between molds shall be divided into three classes, which shall be known as *bull ladle aisles, hand ladle aisles* and *buggy ladle aisles.*

Section 1.—Entrances to foundries shall be protected from Nov. 1 to April 1 of each year by a covered vestibule, either stationary or movable, which shall be so constructed as to eliminate drafts and of such dimensions as to answer ordinary purposes, such as the passage of wheelbarrows, trucks and small industrial cars. This regulation shall not apply to entrances used for railroad or industrial cars handled by locomotives or motors, or for traveling cranes, horse-drawn vehicles or automobiles; these entrances may remain open only for such time as is necessary for the ingress and egress of such cars, trucks and cranes, horse-drawn vehicles or automobiles. No locomotive shall be permitted to remain inside the factory during the loading or unloading of the cars.

Section 2. — Main gangways, where metal is carried by hand, bull or truck ladles, shall not be less than 5 feet wide. Truck ladle gangways which are not main gangways shall not be less than 4 feet wide. Bull ladle aisles between floors shall not be less than 3 feet wide. Single hand ladle or buggy ladle aisles between floors shall not be less than 18 inches wide. Where trolleys are used over molding floors for pouring metal, the aisles shall be of sufficient width to permit the safe ingress and egress of employes and the safe use of the ladles. Where it is necessary to occupy the central portion of the floor space in the production of castings, continuous gangway space shall be provided.

Section 3.—During the progress of casting, every gangway or aisle shall be kept entirely free from undue dampness or obstructions of any nature. Every gangway shall be kept in good condition at all times. Every gangway where industrial trucks are used shall be constructed of a hard material of substantial character and the top of the rail shall be flush with the floor.

Section 4.—Where smoke, steam, gases or dust arising from any of the operations of the foundry are dangerous to health or eyes and where a natural circulation of air does not carry off such smoke, steam, gases or dust, there shall be installed and operated hoods, ventilators, fans or other mechanical means of ventilation.

Section 5.—The cleaning and chipping of castings shall be done in cleaning rooms except that where traveling cranes or where, in existing installations cars are used for conveying castings into such rooms, a separating partition shall be erected which shall not be less than 12 feet in height. In existing installations, where the crane cage or crane girders will not permit the erection of a 12-foot partition, the height of the partition may be reduced sufficiently to permit of the clearance of same. Large castings may be chipped or cleaned by hand in the molding and casting room, provided sufficient protection is furnished by the use of a curtain or screen or some other means equally good to protect employes who are otherwise employed therein. This regulation shall not apply if mechanical contrivances are used for cleaning castings and the dust and particles arising therefrom are effectively removed at the point of origin by means of an exhaust system.

Tumbling Mills

Section 6.—Where tumbler mills are used, exhaust systems shall be installed to effectively carry off the dust arising from the cleaning of castings except where the mill is operated outside the foundry. This regulation shall not prohibit the use of a water barrel to clean castings. Sand blast operations shall be carried on in the open air or in a separate room used solely for such purpose. The milling of cupola cinders, when done inside the foundry, shall be carried on by an exhaust mill or water mill.

Section 7.—The floor beneath and immediately surrounding the cupola shall slope and drain away from the base of same.

Section 8.—Cores shall not be blown out of castings by compressed air unless such work is done outside the foundry or in a special room or dustproof enclosure. Men employed in cleaning castings by compressed air or sand blast shall wear eye guards and helmets.

Section 9.—Where natural light is insufficient properly to light the foundry, artificial light of sufficient power shall be provided.

Section 10.—Interior walls of foundries shall be whitened, in the discretion of the Industrial Board.

Section 11.—Proper and sufficient heat shall be provided and maintained in every foundry. Open fires may be used for the drying of molds or cores if coke containing less than 1 per cent of sulphur is used; also charcoal, gas or oils may be so used; where practicable, such drying of molds or cores shall be done at night.

Section 12.—All hand and bull ladles shall be dried in ovens or outside of the foundry. A sufficient number of sheet iron shields shall be available in iron foundries for use in covering hand bull ladles.

Section 13.—Suitable facilities shall be provided for the thorough drying of employes' clothing. Such facilities may be located in the wash room, the locker room, or in a room used exclusively for such purpose.

Sanitary Conveniences

In each foundry in which 10 or more persons are employed or engaged in labor, there shall be provided and maintained for the use of said employes in a place conveniently accessible and connected with said foundry in such a manner that access thereto can be had without exposure to the open air, a toilet room of suitable size wherein said employes may change their clothes; such toilet rooms shall be provided with wash bowls of sufficient capacity adequately equipped with hot and cold water service; such wash rooms shall be kept clean and sanitary and shall be properly heated during cold weather. There shall also be established and maintained separate from said toilet rooms, a suitable water-closet. The said toilet room and the said water-closet shall be connected with the foundry building in such a way that access thereto may be had without exposure to the open air and shall be properly heated, ventilated, cleaned and protected from the dust of such foundry.

Section 14.—Water-closets shall be provided in every foundry and for each sex, according to the following table:

No. of persons.	No. of closets.	Ratio.
1 to 10	1	(1 for 10)
11 to 25	2	(1 for 12½)
26 to 60	3	(1 for 16⅔)
61 to 80	4	(1 for 20)
81 to 125	5	(1 for 25)

For every unit of 45 or fractional part thereof in excess of 125 persons employed, one additional water-closet shall be provided.

Section 15.—One urinal shall be provided for 30 employes or less; two for 80 or less, and thereafter one urinal shall be provided for every 80 employed or fractional part thereof.

Section 16.—Wash basins with faucets

for hot and cold water shall be supplied according to the following table:

No. of persons.	No. of wash basins.	Ratio.
1 to 8	1	(1 for 8)
9 to 16	2	(1 for 8)
17 to 30	3	(1 for 10)
31 to 45	4	(1 for 11¼)
46 to 65	5	(1 for 13)

For each additional 25 employes at least one additional wash basin shall be supplied.

Section 17.—Wash rooms hereafter installed where 20 or more men are employed shall be provided with at least one shower bath with an ample supply of hot and cold water, and for every additional 50 men one additional shower bath shall be provided.

Section 18. — Individual lockers, arranged for locking, shall be provided for employes and shall be placed in a room used exclusively for such purpose, in the wash room, the drying room or at convenient places in the molding room. In cases of dispute the necessity for, and the number of, such lockers shall be determined by the Industrial Board.

Maintenance

Section 19. — Ladles, shanks, tongs, slings and yokes, skimmers and slag hoes used in the pouring of molten metal shall, prior to their use, be inspected daily as to their safety, by the men preparing and using same; and in addition a regular inspection as to their safety shall be made once a month by a man designated for that purpose. A monthly inspection shall also be made of the chains and cables on counterweights used in connection with drying ovens. Reports of such monthly inspections shall be made on forms prescribed by the Industrial Board and shall be kept on file for their examination.

Section 20.—All fire ways connected with drying ovens, when built in the floor, shall at all times be protected by either a substantial protecting cover or a standard railing.

Section 21.—All trap doors shall be guarded when open, either by standard railings, as described in Section 20, or watchmen, and all pits shall be properly covered or railed when not in use, and sufficiently guarded at other times.

Section 22.—All passageways and stairways shall be properly lighted and inclined runways and stairways, charging decks and platforms shall be safeguarded with standard railings as described in Section 20.

Section 23.—All ladles pouring from the lip, of 2,000 pounds capacity, or more, shall be equipped with a worm geared device for tilting the same. All ladles not so equipped, shall be changed to conform with the above regulation on or before Sept. 19, 1917. All crane truck and trolley pouring ladles shall be so constructed that the center of gravity shall be below the bail unless ladles are equipped with a geared device approved by the Industrial Board; and shall be equipped with a clip to prevent overturning.

Section 24.—Trunnions on flasks shall be capable of sustaining the loads they are required to handle. Trunnions hereafter constructed shall be carefully designed to carry the load they are to handle and constructed with a factor of safety of at least 10, including bolts where they are used. The diameter of the button shall be equal to the diameter of the groove plus one and one-half times the diameter of the sling used to handle the flask. Inside corners shall be well filleted and in order to prevent the sling slipping off or riding the button, the radius of the corner between groove and button shall be approximately equal to the radius of the sling used, the remainder of the inside edge of the button to be straight. All trunnions constructed after Oct. 1, 1915, shall bear the date of their construction.

Section 25.—The use of high explosives on the foundry premises for the breaking of castings is prohibited unless effective protection is provided.

Section 26.—The breaking of castings by the use of a drop inside the foundry during working hours is prohibited.

Where a drop is used for the breaking of castings or scrap outside of the foundry a permanent shield of heavy planking or other effective protection shall be provided.

Section 27.—Every employe shall use safety devices furnished for his protection by the employer, where there is a hazard connected with his employment.

Section 28.—Where rooms in which core ovens are located adjoin rooms where cores are made by females and where the making of cores and the baking of cores are simultaneous operations, the partition between such rooms shall be constructed of concrete, hollow tile, brick, metal, or other material approved by the Industrial Board and there shall be in such partition only such openings as are required by the nature of the business.

Section 29.—All openings in partitions between the core oven room and the room in which females are employed shall be vestibuled with a revolving device or double doors which shall be self-locking, or any other self-closing device equally effective, which shall be approved by the Industrial Board. Such device shall be kept in such condition that gases, fumes, and smoke shall be effectually trapped.

Section 30.—No female shall be allowed to handle cores which have a temperature of more than 110 degrees Fahr.

Section 31.—No female shall be permitted to make or handle cores when the combined weight of core, core box and plate at which she is working exceeds 15 pounds.

Brass Foundries

The term *brass foundry* shall mean a place where brass, aluminum, copper, tin, zinc, gold, silver or composition metals containing any of the foregoing metals are melted or poured into molds in the making of castings, except that foundries where aluminum only is melted shall be covered by regulations governing iron and steel foundries.

The term *cellar* when used in these regulations shall mean a story more than one-half below the level of the ground surrounding the building.

The term *basement* when used in these regulations shall mean a story partly, but less than one-half below the level of the ground surrounding the buildings, and shall be considered the first story of such building.

Section 32.—The regulations relative to dust, smoke, gases or fumes, ventilation, sanitation, heat, light, gangways and aisles, safety appliances, washrooms, cleaning rooms, drying and locker accommodations, as specified for iron and steel foundries, shall apply to brass foundries, except that main gangways shall not be less than 4 feet wide and gangways between molds on spill troughs shall not be less than 3 feet wide.

Section 33.—When the crown plate of an upright melting furnace is elevated above the surrounding floor in excess of 12 inches, the furnace shall be equipped with a platform guarded with a standard railing; and such platform shall be constructed of metal or other fire-resisting material, and shall extend along the front and sides of the furnace, flush with the crown plate and shall be at least 4 feet in width and shall be clear of all obstructions during pouring time. If the platform is elevated above the floor in excess of 12 inches the lowering from same of crucible containing molten metal shall be by mechanical means.

Section 34. — When the combined weight of a crucible, tongs and molten metal exceeds 100 pounds, it shall be removed from the furnace and deposited on the floor by mechanical means.

Smoke Finish

Section 35.—When smoke finish is desired on molds made on benches or tubs, smoke boxes which shall effectually trap the smoke shall be used; such boxes to be connected with flues to the outer air.

Section 36.—When molders work side by side at least 5 feet of space sideways shall be allowed for each man, and a clear space of 3 feet shall be provided back of each man.

Section 37.—Hoods shall be provided directly above all brass melting furnaces using gas or oil as fuel, which will effectually trap all gases and fumes generated in the melting of the metal; such hoods shall be provided with outlet pipes to lead the gases or fumes to outer air.

Ventilators shall be provided over all other furnaces used for melting brass or composition metal, to effectually remove the gases above the furnaces.

Section 38.—Brass foundries shall be provided with natural light from at least two sides or from at least one side, and skylights in roof.

Section 39.—All persons removing pots containing molten metal from furnaces or handling such pots shall be provided with protection for legs and feet.

Section 40.—Gangway dirt and floor scrapings shall not be riddled in the room where workmen are employed, unless it is so dampened as to prevent dust arising therefrom.

Section 41.—Stoves for drying molds, when located in the rooms used by workmen, shall be surrounded by a casing of fire-resisting material, to the full height of the stove at the discretion of the Industrial Board.

Section 42.—No brass foundry shall hereafter be constructed with a clearance less than 14 feet between the lowest point of the ceiling and the floor, except that where a peak, saw tooth, monitor or arch roof is constructed the side walls may be of a minimum height of 12 feet.

Section 43.—No foundry shall hereafter be located in a cellar or basement unless the ceiling shall be at least 14 feet in height, measured from the finished floor to the under side of the ceiling; and, if the foundry is located or intended to be located entirely in the front part of the building unless the ceiling shall be in every part at least 6 feet 6 inches above the curb level of the street in front of the building; or, if the foundry is located or intended to be located entirely in the rear part of

the building, or to extend from the front to the rear, unless the ceiling shall be not less than 3 feet above the curb level of the street in front of the building, and the foundry shall open upon a yard or court which shall extend at least 6 inches below its floor level; nor unless proper and adequate provisions shall be made for lighting and ventilation.

Section 44.—In case any foundry that was legally operated in a cellar or basement on Oct. 1, 1915, shall be discontinued or closed by the department, it can thereafter be reopened as a foundry only by complying with the provisions of the regulations relating to future foundries. The occasional use of a foundry for the purpose of evading this regulation shall not be deemed a continuance of use thereof.

Perpetual Inventory of Rough Castings

By H A Russell

THE HEAD of the production department of a foundry always should be able to turn to his card records of foundry output and ascertain therefrom at a glance the actual standing of any of the production orders for castings. The records should indicate the actual daily status of orders, showing clearly whether the loss by defective castings is excessive or whether the specified quantities are being seriously over-run. The records also should show whether castings that are needed to keep the balance of the factory busy are being received in sufficient quantities to prevent a break in the plans which have been made through consultation between the head of the production department and the foremen. Maintaining an inventory of rough castings is one of the most difficult problems for foundrymen to solve. The reason for this is that a great many of the castings are small, in many shops weighing only a few ounces to several pounds. In our shop the number of patterns exceeds 30,000 and a large number of these is required for repairs only. Unless the records are accurate, there always will be a surplus or shortage of castings, but this system in our plant has given accurate results after a trial of several years. To carry out this system, it first is necessary to obtain an actual report of the number of rough castings which are immediately at hand. The totals are entered on a 3 x 5 card, Fig. 1, in a column headed *Amt.* This card is the permanent production record form. After this information has been obtained, the quantity of castings to be ordered from the foundry is entered on the form, *A*, Fig. 2, entitled "Production Record of Castings". This form consists of two parts; the original, which is ordinary white paper carbonized on the back, and the duplicate, of light-weight cardboard. The duplicate is the molder's work card and the two are padded in lots of 35, being perforated at the top, the upper edge being stapled. When the originals and duplicates are torn off from the pad they are 3 x 5 inches, a standard size for filing. The originals are kept in the office and are filed numerically according to pattern number under the machine name index card. The duplicates are handed to the foundry foreman with instructions regarding the ones which are the most important. Form *A*, Fig. 2, has the word *Rush* printed diagonally across its face in red ink and this same signal is printed on the duplicate. Other forms also are used without the word *Rush* printed thereon. When the foreman is ready to place the cards with the molders, they are distributed by the foundry time clerk. When the molders finish their day's work, the quantity of castings made is entered on the cards in lead pencil. Subsequently, after the castings are counted, the molders are notified of the number of defectives. When the total of good castings made equals the quantity specified on the card *A*, Fig. 2, it is returned to the foreman, indicating to him that the production order has been filled. From the foundry the rough castings are distributed to the other departments and in each a count is made of all castings received and these are entered on the "Goods Received" blank, Fig. 3, which is 8½ x 11 inches. This form is delivered to the production department, which enters daily the castings received by all departments. These entries also are made on the original production record of castings, form *A*, Fig. 2. When the total received equals the amount ordered, this constitutes a quick check

Article X308 Sect. D Row 3 Bin 7
Low Limit 100 Desireable Order 500 Used on Drills
Weight 1# Material N.S. No. per Machine 2

Date	Ordr No.	Amt.	Date	Recd.	Date	Deld.	On Hand	Date	Recd.	Date	Deld.	On Hand
6/9/15		90	6/9/15	41			131					
6/9/15	1410	500	6/11	91			222					
			6/12	98	6/12	40	280					
			6/15	92	6/15	60	312					
			6/16	80			392					
			6/18	95	6/18	52	435					
			6/19	30	6/19	60	405					
				527	6/21	54	351					
					6/22	60	291					
					6/24	3	288					
					6/25	60	228					

Form 319 P—7-28-13—3000

PRODUCTION RECORD OF CASTINGS #1410
PATTERN NO. X308 DATE ORDERED 6/8/15
FOR MACHINE Drill
PART NAME Grain Cup
NUMBER REQUIRED 500

Made Good	41	95
Made Good	91	30
Made Good	98	527
Made Good	92	
Made Good	80	
No. Bad		

RUSH

(A)

MOULDERS WORK CARD #1410
PATTERN NO. X308 DATE ORDERED 6/8/15
FOR MACHINE Drill
PART NAME Grain Cup
DATE COMPLETED 6/18/15 NUMBER REQUIRED 500

Made Good	41	95
Made Good	91	30
Made Good	98	527
Made Good	92	
Made Good	80	
No. Bad	2	1 3

RUSH

(B)

MAN'S NO 261 TOTAL GOOD 527 WEIGHT 1 PIECE 1# TOTAL WEIGHT 527#
WHEN ORDER IS COMPLETED RETURN ORDER TO FOUNDRY OFFICE

FIG. 1—PERMANENT PRODUCTION RECORD CARD

FIG. 2—THE PRODUCTION RECORD OF CASTINGS IS SHOWN AT *A* AND *B* IS THE MOLDER'S WORK CARD, THE DATA ON WHICH ARE TRANSFERRED BY CARBON FROM THE ORIGINAL *A*

against an over-run in the foundry. When the casting reports are received each day, corresponding entries are made on the permanent record card.

Castings which prove defective after being shipped from the foundry or which are spoiled while in process of machining, are placed in a bin which is the receptacle of bad or spoiled castings from all departments except the foundry. Under no conditions are spoiled or bad castings thrown direct on the scrap pile, either on the cupola platform or in the yard. A violation of this order is considered a serious breach of shop discipline.

If a casting is found to be defective through carelessness in molding, the amount originally paid for the work is charged against the molder who made the casting. The scrap casting bin is emptied periodically, but not until the machine shop and the foundry foreman have had an opportunity to inspect its contents. After the castings are machined, the number is entered in the column headed *Del'd.*, Fig. 1.

For the purpose of recording the number of rough castings on hand each casting, as machined, is considered in the same manner as if it had been shipped from the plant.

To enable the production department to obtain prompt reports of all spoiled or defective castings which develop after the rough castings have been shipped from the foundry, a form, Fig. 4, is used which not only contains a complete description of the casting scrapped, but also notes the reason for its rejection. If the casting is defective the word *spoiled* is crossed out and if spoiled during the machining operation, the word *defective* is crossed out. This slip is returned to the production department after it is signed by either the foreman or assistant foreman and the proper entry then is made therefrom.

Spongy Piston Castings

By W. J. Keep

Question:—We are experiencing difficulties in casting pistons, which leak around the inside braces and it seems as if the metal draws away from these parts. Some of the mixtures we have used follow:

Silicon, 1.75 per cent; sulphur, 0.042 per cent; manganese, 1.11 per cent; phosphorus, 0.32 per cent. This was all pig iron.

Silicon, 1.56 per cent; sulphur, 0.045 per cent; manganese, 0.92 per cent; phosphorus, 0.25 per cent. This likewise was all pig iron.

Silicon, 1.30 per cent; sulphur, 0.064 per cent; manganese, 0.81 per cent; phosphorus, 0.244 per cent. This mixture consisted of 700 pounds of scrap and 1,300 pounds of pig.

Silicon, 1.40 per cent; sulphur, 0.045 per cent; manganese, 1.08 per cent; phosphorus, 0.20 per cent. This again was an all pig iron charge.

We are experiencing no trouble with our regular castings or large semi-steel cylinders.

Answer:—In a paper presented before the American Foundrymen's Association, John Jermain Porter recommends the following analysis for piston castings: Silicon, 1.50 to 2 per cent; sulphur, under 0.08 per cent; phosphorus, 0.30 to 0.50 per cent and manganese, 0.40 to 0.60 per cent. It will be noted in your mixtures that manganese is the only element which is higher than this analysis, while the phosphorus is lower. The trouble evidently is not with the composition of your mixture, but probably the pattern should be changed to effect the setting of all parts of the casting at the same time. Where the ribs join the body of the piston there is a greater mass of metal and this cools after the rest has become solid, resulting in the iron drawing away from that which already has set. If the pattern cannot be changed, chills must be employed to cause the metal to set at these points. Try chills on the inside, but if these make the metal too hard for machining, then place chills in the cores, which will chill the exact spot where the trouble occurs.

Describes Products

The Jones Paint Co., Rome, N. Y., has recently issued a number of attractive booklets describing its products. Under the caption "A Feather in Our Cap" photographs are presented showing orders received from a large number of the leading iron and steel companies for the company's paints. Another interesting folder reproduces the sworn statement of a public accountant, showing that in the last 10 years, 95 per cent of the buyers of the Jones company's paint have re-ordered.

GOODS RECEIVED

DATE June 10—1915

PIECES	DESCRIPTION
70	x249 Cup
910	2 T. L. H. Washer
41	x308 Grain Cup
211	F904 Gear
87	W7 Shield
14	F411 Gear
17	x409 Stud
141	D49 Spider
92	x191 Dustband
71	W14 Brace

SIGNED Mc.

SEND DAILY TO PRODUCTION DEPARTMENT COPY OF THIS REPORT

FIG. 3—SHEET FOR ENTERING GOODS RECEIVED

CLASSIFICATION No. 9 DATE 6-24-15

SPOILED OR DEFECTIVE PARTS

PATTERN No. 1308 PATTERN NAME Grain Cup

PIECES 3 TOTAL WEIGHT 9# MATERIAL R.I.

LAST OPERATION Drilling PERFORMED BY MAN No.

REASON FOR SCRAPPING Used wrong size drill

SIGNED L. B. S.

USE SEPARATE SHEET FOR EACH PATTERN CROSS OFF EITHER "SPOILED" OR "DEFECTIVE" AS CASE MAY BE

FIG. 4—SPOILED OR DEFECTIVE PARTS REPORT

Death of J. G. Hendrickson

Joseph G. Hendrickson, founder of the Ajax Metal Co., Philadelphia, and chairman of the board of directors, died Nov. 4 in that city, at the age of 69. Mr. Hendrickson retired as president of the company about a year ago, when he was elected chairman of the board of directors, which office he also occupied with the Ajax Metal Co. of the South, Birmingham, Ala. He was president also of the Ajax Lead Coating Co. The Ajax Metal Co. was established in 1880.

The Sprague Electric Works of the General Electric Co., New York City, has established a sales office in the Provident Bank building, Cincinnati. Frank H. Hill, is manager.

Recent Improvements in Foundry Operations---I

An Analysis of the Causes Which Have Led to a Wider Use of Labor-Saving Devices in Casting Plants—Development of the Molding Machine

By Thomas D West

The accompanying paper is the last contribution of the late Thomas D. West to the foundry literature which he did so much to enrich. It is significant that the subject of the paper should treat of the recent advances and improvements in the art of founding, for few men have done more than Mr. West to advance foundry practice. The paper was read at the recent meeting of the International Engineering Congress at San Francisco, nearly two months after Mr. West succumbed to injuries received in an automobile accident. Among the most notable works written by Mr. West are "American Foundry Practice", now in its twelfth edition; "Molder's Text Book", now in its tenth edition; and "Metallurgy of Cast Iron", now in its fourteenth edition.

IMPROVEMENTS in the construction of foundries and their appliances, to cheapen the production of castings made from ferrous and non-ferrous metals, has been of a steady, persistent and increasing character, since the introduction of electricity and compressed air as a motive power. This advancement of founding has led to the creation of many new auxiliary industries that demand the employment of many persons possessing more or less of an engineer's education, combined with their having some fair, practical knowledge of the needs of founding.

Before these auxiliary industries commenced to supply foundries with their equipment, all such was made by the foundryman himself or was obtained from outside jobbing shops. The starting of industries to make a specialty of producing foundry appliances in their neatest and most practical form, caused many foundrymen also to devise improvements, resulting in a rivalry that has been chiefly responsible for the installation of the labor-saving appliances seen in modern foundries today. In keeping with the improvements for handling raw materials for founding, there are those for mixing, melting, molding, coremaking and cleaning of castings that have, in the past three decades, greatly revolutionized old methods for the performance of this work.

The improvements in producing ferrous and non-ferrous metals have been greatly assisted by chemical studies, both by makers and users, of the percentages of the elements contained in them, instead of producing metals by guesswork, and then being guided by the appearance of fractures to judge the grades desirable for making castings. The advancement in coremaking and molding has been due to a few gaining a fuller understanding of the principles involved in the art of founding, to the use of better equipment for handling molds and to the use of molding machines.

The cleaning of castings has progressed sufficiently to keep fully abreast of the other machine manipulations in founding, due mainly to improvements in tumbling barrels and to the invention of sand blasting, pneumatic and hydraulic tools and electrical appliances specially designed for foundries. In connection with the great improvements of appliances to produce better castings

Presented at the San Francisco meeting of the International Engineering Congress.

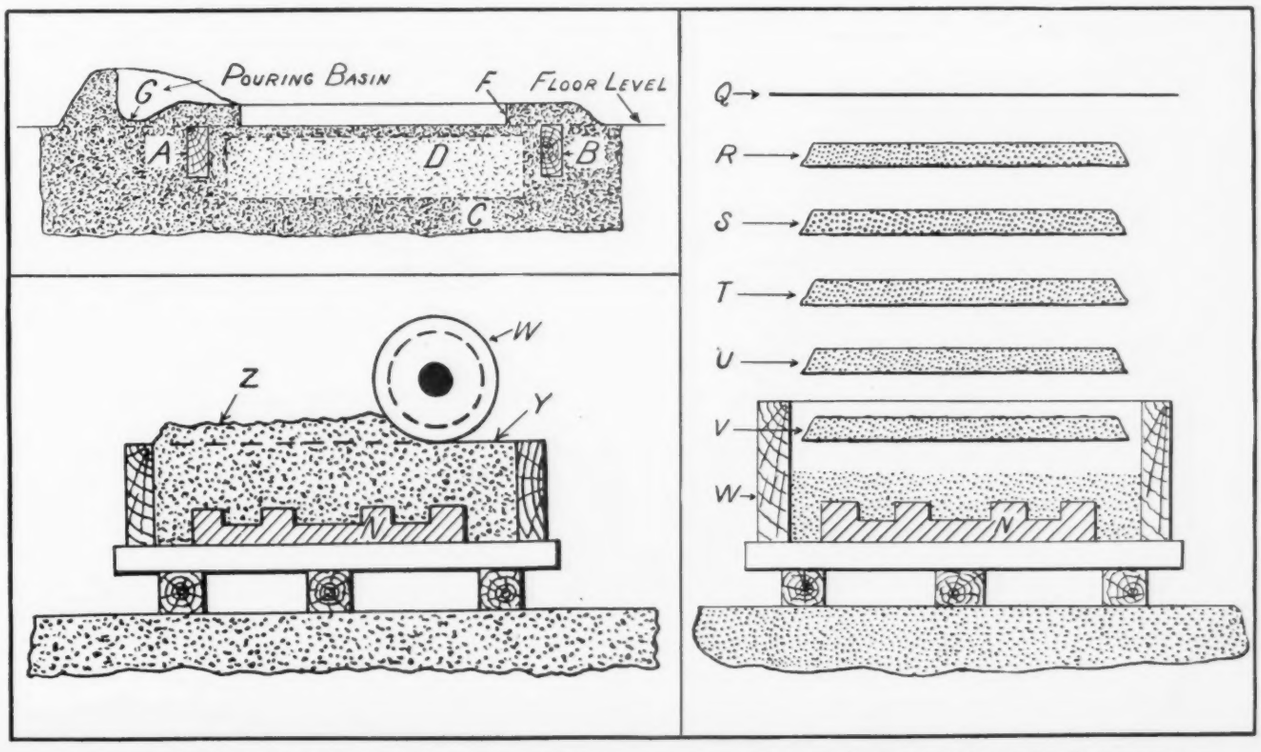


FIG. 1—CASTING OPEN SAND PLATES ON A SOFT BED
FIG. 2—ROLLER COMPRESSION OF SANDS TO RAM MOLDS

FIG. 3—PACKING MOLDS WITH FALLING BODIES OF SAND

and cheapen their production, we have the almost universal adoption of specializing, wherever such can be done to any advantage, to reduce the cost of manufacture still further.

The improvements in all the varied machine operations of founding and the adoption of specializing have been so vast of late years that it is entirely out of the question to undertake their description in detail in a single, or even several large papers. However, as some one or two of these features may be considered fairly comprehensively in a single paper, I will confine this one principally to a treatment of constructing foundries and the use of molding machines and other labor-saving appliances in connection with means to improve the quality of castings.

Any extended inspection of foundries of today will show that the most revolutionary factors which have brought about improvements in the art of making castings, have been the radical departures in the designs of foundries and the methods for handling molds and castings. Often rather absurd features have been installed in the thought that they would prove economical in the production of castings. Thousands of dollars have been spent in endeavors to utilize equipment for handling molds and to mix and convey sand to them, which would not only increase the cost of producing the casting over hand labor, but, in some cases, be so entirely impracticable as to be finally discarded. There has been failure on the part of many foundrymen to recognize the difference which must exist in the design of a plant for handling molds and liquid metal as compared with one intended to make pins and needles, railroad rails or tin cans by machinery, wherein all the raw materials can come in at one end of the factory and have little or no interference to prevent their going out at the other end in due course of time, a finished product.

The sand and dust of a foundry, in connection with the frail character of sand molds and the demands for instant action when the liquid metal to pour them is at hand, are all factors which must have full consideration in the design of a plant. Any proposition for equipping a foundry with complicated appliances, based upon experience in other industries, is apt to lead to trouble. It is always well for engineers or inexperienced founders to be guided partly, if not wholly, by those of intelligence who have been brought up in the actual work, instead of ignoring all such counsel and going ahead egotistically, as some have done to their sorrow and loss.

There are problems in the designing and use of molding machines, as in the construction of foundries, that should be considered from the viewpoint of the experienced foundryman, if optimistic opinions as to the general advantages of machinery over hand labor are not to be allowed to blind the designer as to practical operating conditions which must be met.

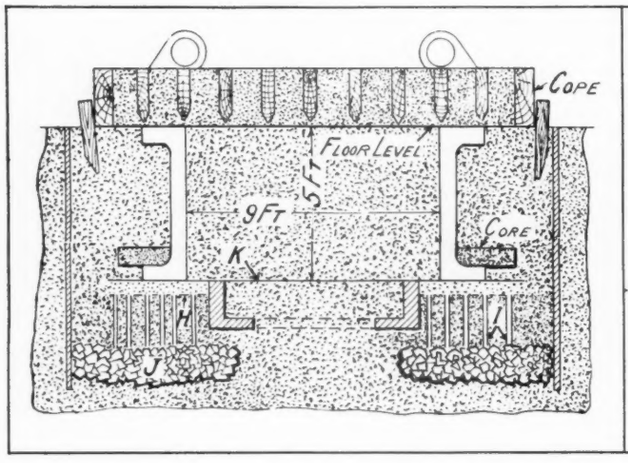


FIG. 4—CASTING 9-FOOT PIPE IN GREEN SAND WITH LOWER FLANGE ON HARD BED

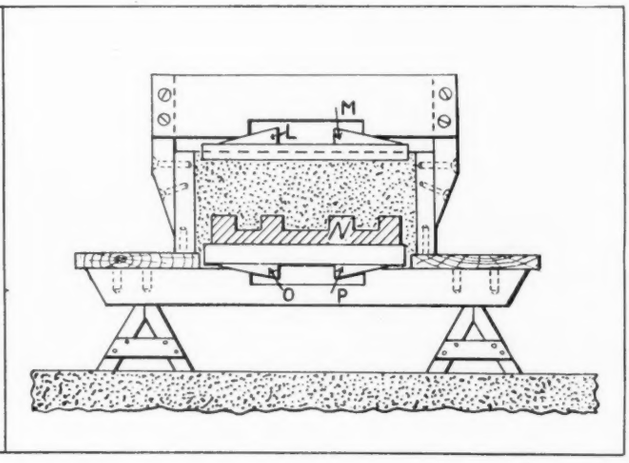


FIG. 5—REVERSIBLE ACTIONS IN SQUEEZING MOLDS

Advantages of Molding Machines

Not long ago the writer made a special inquiry of a number of foundries to learn the extent to which they had adopted molding machines and the views they held as to their advantages. I can best impart information obtained from these sources by publishing extracts from a few of the letters received, which I will place here under numbers, as follows:

No. 1 states, "We have increased our melt from a maximum of about five tons per day to 17 tons per day and our entire increase has been due to our using molding machines. All of the men who run these machines were simply handy men that we broke in ourselves and we have never had these machines operated by a regular molder."

No. 2—"We have about 75 men whom I consider molders, the balance, about 125 men, are men that we have broken in on special jobs such as molding machines, follow-board work, etc."

No. 3—"When our foundry is running to its full capacity, we produce about 25,000 tons per year and employ from 175 to 200 molders. It probably will interest you to know that we have not one molding machine in our plant, unless you would so classify a few of the original old-fashioned squeezers, and we know that we are producing as much per capita and doing the work at as low a cost as our competitors who are using machines on certain classes of work."

The following are what can, more strictly than the above, be termed jobbing foundries: No. 4 employs 84 regular molders and 10 molding-machine operators; No. 5 engages 24 regular molders and 10 machine operators; No. 6 has 80 men making molds, 15 of whom are machine operators; No. 7 has 78 skilled molders and 40 handy men working on machines; No. 8 states they have 120 regular molders and 50 machine operators.

A study of the above diversity in the employment of regular molders and machine operators shows it to be greatly dependent upon the following seven features: First, the character of the work; second, the design of foundry; third, the scarcity of skilled molders, compelling proprietors to train handy men to make their molds; fourth, indifference of some firms to encourage installation of improvements; fifth, differences in the ingenuity of the supervisory force to devise ways and means whereby certain castings can be made

on machines; sixth, keen competition compelling founders to utilize molding machines; seventh, whether a shop is closed or open in regard to unionism.

In case No. 3, we have a condition displaying the difference in the achievements of shops that may easily exist, due to one shop having a thoroughly broad, experienced and good executive production manager, while another concern may be lacking in this regard. However, it may often be a question whether, if such an able management should decide to utilize molding machines, the results obtained with the machines would not be ahead of those of the average foundry which has adopted machines.

The plan of constructing patterns, mold boards, flasks, core arbors, and methods for handling the molds, have often more to do with making possible the production of intricate forms of castings by the use of molding machines, and at a greatly reduced cost over hand labor, than the actual machines themselves. Nevertheless, the great accomplishments in reducing costs of production could not be obtained without using molding machines, no matter how ingenious the able foundryman may be in devising ways and means to do so.

The question has been raised whether the increasing use of molding machines would not in time do away entirely with the need for highly skilled or broadly experienced molders. While molding machines continue to displace the "regular molder", there is nevertheless a very large and varied class of work for which molding machines have not been utilized, especially in jobbing foundries. It is safe to affirm that the services of a large number of "regular molders" will always be in demand, some of whom will need as high skill and ingenuity as are demanded in any line of mechanical industry.

There are two methods for making molds. One of these comprises what is called "bedding in". This demands that the pattern be placed in the position in which its mold will be cast, and sand is rammed in under and around it. The second system, called "rolling over", or "turning over", requires that the pattern be placed the reverse way, the sand being rammed around and on top of it, after which the pattern, the sand and flask are rolled over to bring the mold into the position in which it generally will be cast. Molding machines are chiefly of practical use in rolling over work, which comprises, on an average, fully 80 per cent of the combined production of all foundries.

There are four distinct steps in the use of molding machines for roll over work: First, the ramming of the sand; second, the rolling over of the nowel; third, the ramming of the cope; fourth, the drawing of the pattern. The nowel is the lower body of a mold, while the cope is the upper section, and between the two exists the joint, which, when the cope is rammed on and taken off from the nowel, permits the pattern to be withdrawn from its mold. The nowel and cope are generally rammed independently on the machine by methods which will be considered later. Again, the rolling over of nowels or copes, as well as the drawing of the patterns, may be done, if desired, by following the practice which obtained before the introduction of molding machines.

The ramming of the sand to form a mold is now accomplished by one or all

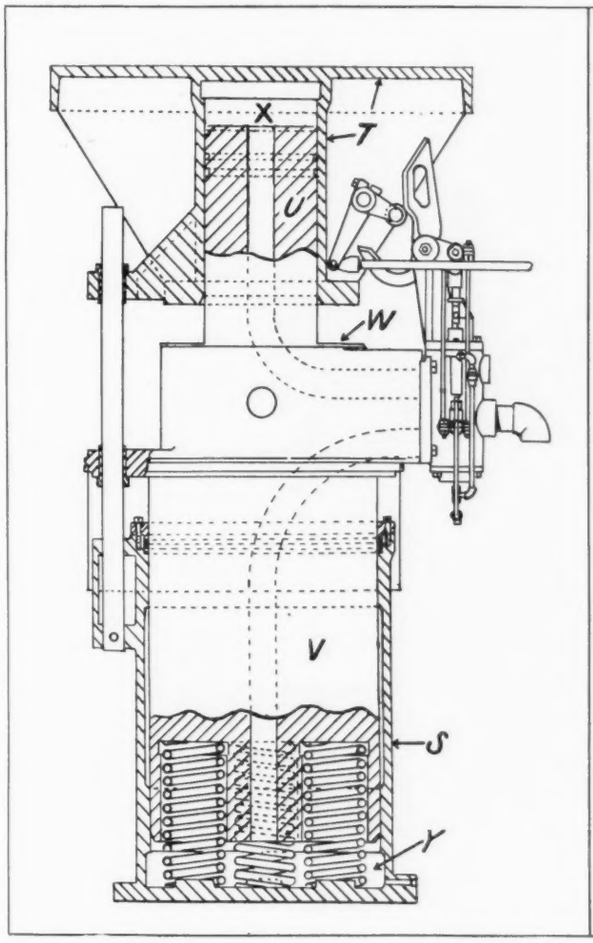


FIG. 6—SECTION OF TABOR SHOCKLESS JAR-RAMMING MACHINE

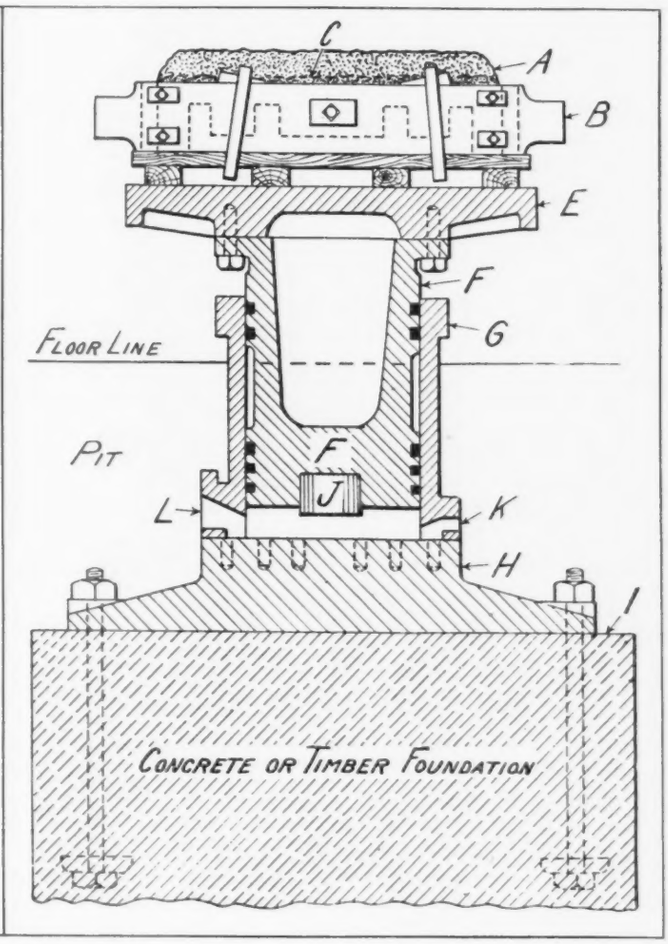


FIG. 7—AN AIR-CUSHIONED CENTER-BLOW JOLT-RAMMING MACHINE

of the following methods: First, hand ramming; second, jar or jolt ramming; third, squeezer ramming; fourth, gravity ramming; fifth, roller ramming.

It is often necessary that the first method, or some hand tucking or ramming, accompany that of the machine, in order to have all parts of a mold properly rammed, or to obtain the different degrees of density that may be desirable at joints, in pockets, cores, projections, etc. The second to fifth methods comprise what is generally called "machine ramming". In this, as in all other lines of machine work, to produce accurate results as to specific densities, the molding machine requires skilled handling; while the hand, with the best skill, finds it difficult to produce or duplicate the uniform degrees of densities required in ramming molds. Because of the delicacy often desirable in obtaining specific densities of sand, it was thought by many that the molding machines would not be very successful. These anticipated difficulties have been overcome to such an extent by combining hand ramming, when necessary, with that of the machine, that there exists little, if any, of the old-time hesitancy to consider the adoption of molding machines.

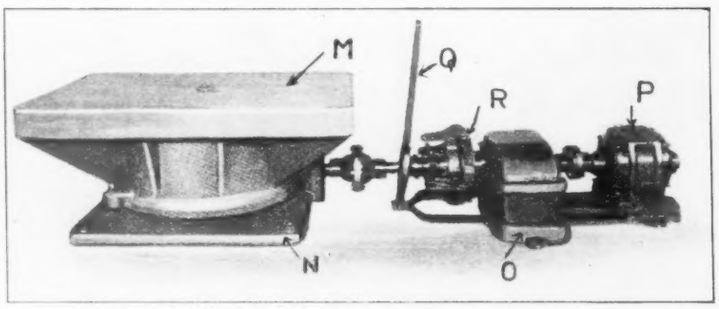


FIG. 8—PRIDMORE CAM JOLTING ELECTRICALLY-OPERATED MACHINE

Aside from the question of the strata uniformity of density obtainable by "machine ramming", we have to deal with that of the reversibility of hardness, or whether it is better for the face of a mold to be of the greatest or the least density to be had by ramming. As this point should be considered in judging of the adaptability of the various machine ramming methods, to enable purchasers of molding machines to select them intelligently, I have taken space here to discuss the subject in its relation to the various types of machines.

The so-called "jar" or "jolt" machine method of ramming molds was originally protected by a patent taken out by Hainsworth, in 1869, having the following broad claim: "The packing of sand, for a mold, in a flask, by raising the same, together with the pattern and letting them all drop upon a hard bed, substantially as shown and described".

There seems to have been very little realization of the merit involved in this jolt method of ramming sand until after the expiration of Hainsworth's patent. This was, no doubt, due to the lack of appliances necessary to make a practical use of the system. Such appliances were, in 1878, patented by Jarvis Adams, but it was not until compressed air became a common medium for the transmission of power that we find jolt ramming machines commanding the serious attention of founders.

Jolt ramming of molds causes the undermost part of the sand in a flask to be the most dense, and from this greatest density at the bottom, or from the face of the mold, there will be a uniform decrease in its compactness to its top surface. This is exactly the reverse of the condition as to bottom and top densities of sand found in roll over molds that are rammed wholly by hand labor. For this reason there was much skepticism entertained by molder foundrymen as to the utility of jolt ramming, it being held by many that the bottom face of a mold should always be softer than its underneath supporting body. Men of broad experience in jobbing foundries were among the first to perceive the error of this belief. To show the practicability of having the face of certain molds the hardest, I illustrate, in Fig. 1, and describe below, the conditions involved in the making of "open sand" castings, a process requiring no top covering or cope.

Open Sand Molds

Wherever castings can be used that are not required to be of an exact thickness and may permissibly be rough on one of their faces, such as castings for floor plates in rolling mills, they may often be made by "open sand" methods, after the plans shown in Fig. 1. Let us presume that the molder is making some plain, plate casting requiring only one face to be smooth, and which may range in area from one foot up to 12 feet, or more, square or round. In making such "open sand" molds, as Fig. 1, without venting, the foundry floor may be excavated to a depth of 6 to 24 inches; the larger the area of the plate casting to be made, the deeper, as a rule, the excavation. The digging having been completed, straight edges *A* and *B* are leveled and fastened in place. This done, loose or riddled sand, as at *D*, is shoveled in to fill the hole, and so as to protrude from a ¼-inch to ¾-inch above the top edge of the straight edges, *A* and *B*. This protruding sand is now packed, by one or more of several methods, to depress it to but a little above the top of the straight edges, after which another straight edge is used to strike the sand off level and smooth with the faces of *A* and *B*. This gives a comparatively hard face to the mold, while all the sand below it is of a less density, as left by the shovel in throwing it gently into the hole. The fact that the sand under the face of the mold is of a soft, porous character, as shown, generally permits the escape of all gases, when pouring the open mold, without the necessity of using vent wires, which are required when such under-bodies of sand are rammed as by hand methods in roll-over molds. If the face of such an open sand mold as Fig. 1 is not made dense, as described, the metal, when running into the mold, would be more apt to form a salamander or bulky irregular mass of sand and iron, than to furnish a casting of the character desired. To illustrate a very radical contrast in density of sand required in certain cases, to that required for the making of open sand castings, a method more in keeping with the hand ramming of roll-over molds, is shown in Fig. 4. This is a pipe casting 9 feet in diameter by 5 feet high, which is being made in green sand. All the sand below the dotted line *H* had to be crammed so hard that the vent holes, *I*, were made by using a hammer to help drive the ¼-inch vent wire down into the cinder bed *J*.

In the making of the first one of these pipe castings, the mold was no sooner filled with metal than its static pressure forced crevices in the bottom of the mold, to such an extent that all the metal escaped to an under strata of quicksand which was some 3 feet below the bottom flange of the casting, and only a few pounds of the several tons of metal were ever found. This fact is mentioned to impress the necessity of there often being radical differences in the densities of the sand forming the bottoms of such molds as those shown in Figs. 1 and 4, as well as in other cases that might be mentioned. It is to be understood that the body face *K* of the mold, forming the lower face of the bottom flange, was rammed but

little harder than the face of the "open sand mold", or not nearly so hard as the underneath body below *H*. The body of sand between *K* and *H* being vented with a ⅛-inch wire down to the large ¼-inch vent holes seen at *I*, permitted the metal to lie quietly on the lower face of the mold, while the stone-like "under-hardness" of the sand below *H* prevented straining of the mold or casting, and avoided any further losses after the experience cited above.

Advantages of the Squeezer

In considering the squeezer method of compressing sand to make molds, whether by pneumatic, hydraulic, electric or hand power, we find that it has an advantage over jolt ramming, in that it permits the face of a mold to be the hardest or the softest portion of the sand comprising it, as conditions demand. These features are illustrated in Fig. 5. Here, by driving the wedges *L* and *M*, the sand is pressed downward upon the pattern *N*, causing the sand to have the least density at the face of the mold. However, we have a strata uniformity in the vertical degrees of density, ranging from one face of the mold's body to the other, similar to that obtainable by jolt ramming. Whether pressing the pattern *N* up into the sand, as by the wedges at *L* and *M*, would be preferable, will naturally depend upon the character of the casting to be made. If neither pressing up or packing down the sand will give the best conditions for the casting to be made, then the vent wire, at some sacrifice of time and labor, may be used largely, if not wholly, to do away with danger of a mild blowing or scabbing, which would result in a defective casting. The practicability and rapid adoption of jolt and squeezer ramming methods, caused inventors, including engineers and founders, to seek for other systems that might be of service in mechanically compressing sand in molds. This resulted in the recent introduction of what are called "gravity" and "roller" methods for packing sand. These systems have been recently installed in a number of foundries and have advantages that commend them for making quite a large range of certain kinds of castings.

The general principle involved in gravity ramming will be understood by reference to Fig. 3. Here, at *R*, *S*, *T*, *U* and *V*, are seen falling bodies of sand coming from a delivery height, as at *Q*, to fill the flask *W*. This method, like the jolt and squeezer methods, requires mechanism to control the operations necessary to obtain the desired ends. A study of Figs. 3 and 5, shows that to make these principles possible of utilization in making various kinds of castings, it is necessary to devise some special ingenious appliances. As these devices are of interest and value to all those seeking to understand the practicability of these systems, some of the latest devices being installed in foundries to make castings by machine operations are described later.

Gravity Ramming Method

The gravity ramming system is one that gives results which differ greatly from the jolt or squeezer methods, in that the dropping of the sand from any chosen height gives a vertically uniform density from the lower face, or the first face to receive the sand, to the upper portion, which is the last to be filled. It can be readily seen that any desired degree of uniform vertical density is obtainable by varying the height of the fall of the sand. A further discussion of these features will be given later.

Roller Compression of Sand

The most recent introduction of machine methods to pack sand in molds comprises the use of a roller, as illustrated in Fig. 2. The roller *X*, has a solid bearing at each of its ends, as at *Y*, and when moved forward and backward the necessary number of times compresses the sand, seen at *Z*, to the desired density in the flask. This roller method produces a result similar to that obtained by squeezers when pressing the sand downward onto a pattern, in that the face of the mold is the softest portion. If the cope face were desired to be the hardest, it is possible, in the case of strictly flat surfaces, to obtain such by the roller method, merely by having the sand compressed downward from the face of the mold and then struck off and trowel finished to give it a smooth face. It is only in the making of thick or massive castings, as a rule, that the cope face requires to be very hard.

For large surfaces, where the castings are under 1 inch in thickness, it is generally desirable to have the cope surfaces, as long as the sand can be held up rigidly, as soft as practicable. This permits the air in the mold and gases in the sand to find a ready release as the metal comes up suddenly to strike the cope's surface. This escape of gas is much freer than if the sand were as compact as it would be if jolt ramming were used, unless there were plenty of venting carried down close to the cope's surface. This roller method of compressing sand has fea-

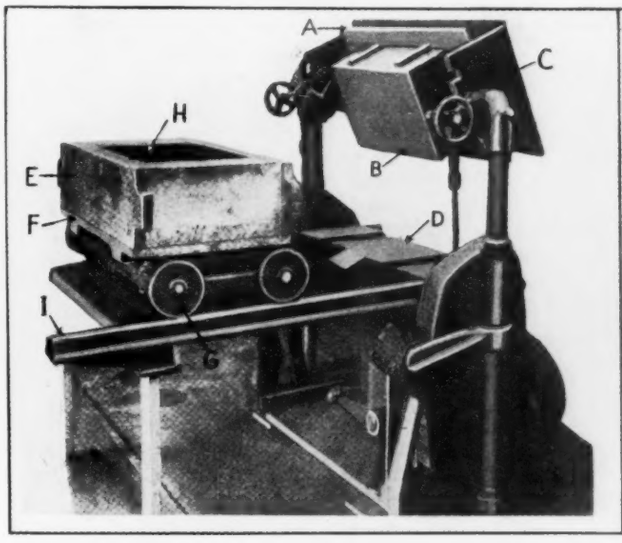


FIG. 9—OSBORN ELECTRICALLY-OPERATED JOLT AND TURN-OVER MACHINE REPLACING PATTERN

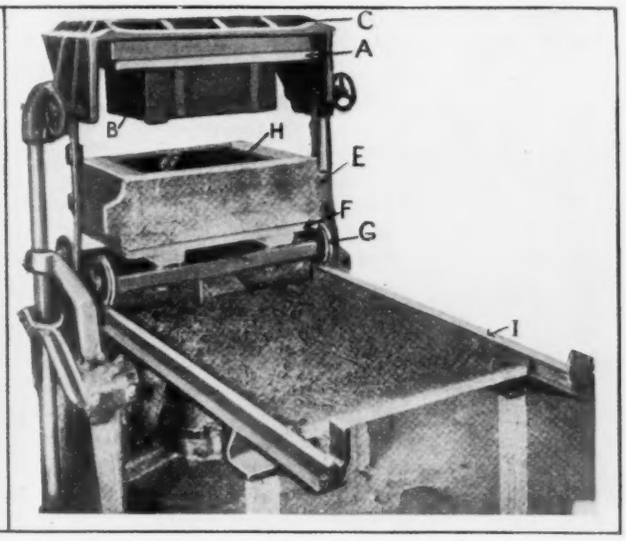


FIG. 10—SAME MACHINE DRAWING A PATTERN

tures that commend it for the manufacture of various kinds of special castings. A very novel and useful appliance for ramming sand that is becoming very popular in modern foundries is the pneumatic hand-rammer. These rammers are used chiefly for what is called "butt ramming". A man will not only do from 20 to 30 per cent more work with this tool than if ramming molds by hand, but will also save himself much hard toil. This latter factor has greatly assisted foundrymen in installing and having these tools used steadily in their plants. These tools are used not only for floor work, but for bench molding. Air pressures of 30 to 100 pounds per square inch can be used to operate them. The pneumatic rammer being attached to a rubber hose makes it convenient for use at any spot over large areas of ground.

Improvements in Jolt Ramming

Fig. 7 is a sectional view of what is considered an advanced type of a good, cushioned, plain, jolt ramming machine. It shows the sand *A* in the flask *B* before it is jolted, and at *C* after the operation is completed. The principal parts of these jolt machines generally consist of the table *E*, piston *F*, cylinder *G*, base *H* and the foundation *I*. The foundation is generally constructed either entirely of concrete or of heavy timber cribbing to cushion the machine's blows and to prevent jarring the ground. The jolt is obtained, in the machine shown, by means of the steel insert *J* striking the face of the base *H*. Some machines make the jolt by the table striking the top of the cylinder, and again by the whole bottom surface of the piston, free of any steel insert, coming down, as a body, to strike the face of the base *H*.

The distance the piston and table are raised in the jolting operations varies, in different machines, from ¾-inch to 2½ inches. The best efficiency is generally obtained, in the character of machines shown in the illustration, by a lift of 1½ to 1¾ inches. These machines are found to be most efficient at a speed ranging from 100 to 160 jolts per minute. A "dead drop" of iron on iron with no rebound is not desirable. This, in its action, would be similar to a person taking two steps forward and one backward to make progress in walking. This feature was one which had to be developed by the test of actual use of the machines. The first machines were found to shatter the solid-rammed sand to such an extent as to make bad molds and produce defective castings, and also made it impossible to attain speed in jolting.

To overcome the above shattering evils, it was found necessary to retard the effects of a "dead drop" to a greater or less degree. This is now achieved by providing a controllable air cushion to partially check the blow of the piston and thereby decrease its deadening effect. Some have so perfected the manipulation of this air cushion as to cause an elastic rebound that carries the piston and table upward in such a way as to have the mold board, pattern and flask *B* respond to the same degree as the sand itself. It is claimed that the recent perfection of these features, in providing a proper cushion for the drop of a piston, has increased the efficiency of earlier jolt ramming fully 100 per cent. In other words, the best type of existing jolting machines will ram about twice as many molds in the same time as the uncushioned machines will.

The raising of the piston *F* and table *E* is achieved, today, either by compressed air, cams, or toggle-joint appliances. Air is used having a pressure of 60 to 100 pounds per square inch, and is, at this time, the chief power used for operating jolting machines. Some machines have an inlet for the air, as at *K*, to be exhausted through another opening, at *L*. Very recent machines have only one opening, which serves for both admission and exhaust. The valves of these latest machines cut off the inlet air before the exhaust opens, thereby consuming less air in jolting the machine. The past few years' rapid advance in the successful use of jolt ramming machines has created a demand for some very large ones.

Fig. 8 shows a plain jolt machine, made by Henry E. Pridmore, Chicago, in which table *M* is operated by a cam, which works in contact with a roller follower forming one end of a bell crank. This whole machine is placed on a solid foundation so that the top face of the table is about 1 inch above the level of the shop's floor. It is electrically driven, the motor being shown at *P*, and is operated at will by the handle *Q* opening and closing the clutches *R*. These machines are made in standard sizes, with tables ranging from about 2 feet to 6 feet square. It is claimed that this electric jarring machine can be operated very cheaply.

Shockless Jarring Machines

An objection sometimes raised against plain jolt-ramming machines, is the shock they transmit to the ground, and the damage it may cause to molds having any hanging bodies of sand in the copes, protruding green sand cores, etc., when the mold is in close proximity to the jolting machines. The shocks may also affect the foundations of buildings and machinery. With a view of eliminating the shock or ground waves created by plain jolting machines, there is made what is termed the "shockless jarring machine", shown in section in Fig. 6. This machine does not require any massive concrete or heavy wooden cribbing to support it. It can be placed on any plain foundation sufficiently solid to sustain its total static load.

The shock of this machine is deadened by a number of heavy springs, shown in its base, and by means of the compressed air used in operating the machine. The jolt action is obtained by the combined cylinder and table *T* working up and down on the piston *U*. This table, in falling, strikes the plunger *V*, which works in the cylinder *S*, at its upper faced bearing, *W*. When the compressed air is admitted to the jarring or jolting cylinder *T* to fill the space *X*, the entire weight of everything, excepting the lower cylinder *S*, is carried by the springs under the anvil, and they are, therefore, compressed and in readiness to expand when the air is exhausted and the table falls. At the beginning of this movement the loaded table is impelled downward with a force equal to that which moves the anvil *V* and *W* upward, and it is claimed that the loaded table and the anvil acquire substantially equal momenta, which neutralize each other when impact takes place.

Use of Combination Valve

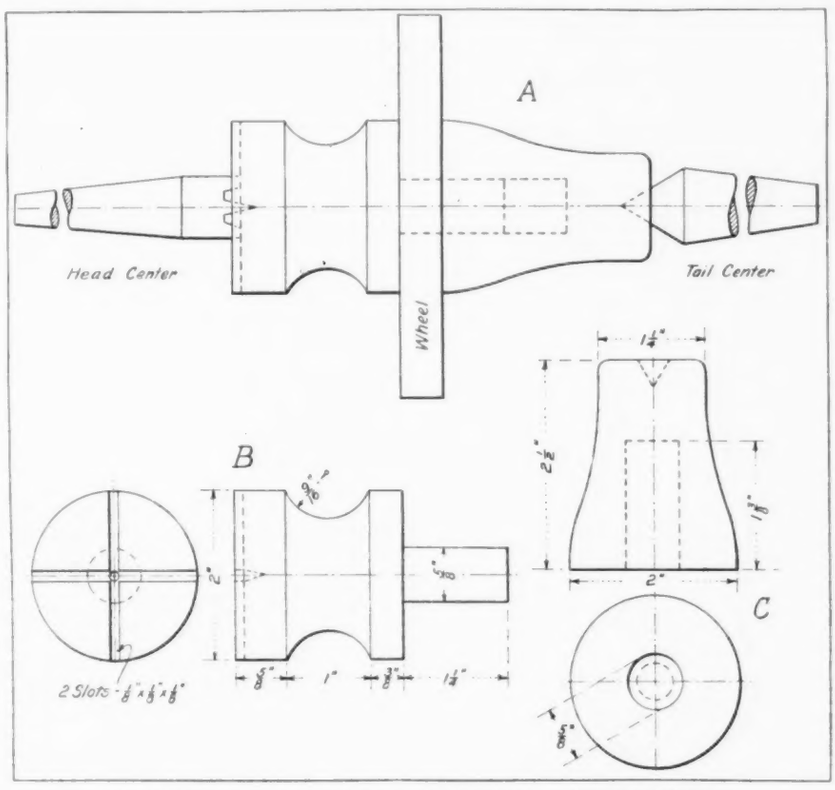
To compensate, in a measure, for the loss of spring pressure as the anvil rises, the exhaust from the jarring cylinder *T* may be carried into the anvil chamber *Y* before being discharged. This is accomplished by a combination valve, consisting of a large main valve of the steam-hammer type in connection with a small pop valve such as is used on small power squeezers and split-pattern machines. These valves are attached to the anvil or plunger base *V*, and the pop valve is opened and closed by tappets on the jarring table *T*. When the table drops, the pop valve opens, admitting pressure beneath the main valve, which rises and puts the jarring cylinder in communication with the air supply, at the same time opening the anvil chamber *Y* to exhaust. When the limit of stroke is reached, the pilot valve opens to exhaust, and the main valve opens to drop the table. The air from the jarring cylinder *T* rushed into the anvil chamber *Y*, expanding to much lower pressure, which is, nevertheless, very effective in the large anvil cylinder, and causes the loaded table *T* and anvil *V* and *W* to collide with greater force and effect upon the sand. The supply of air to these valves is controlled by an air cock at

the operating stand, and the table runs automatically as long as the air is turned on. At the same time, the stroke of the table is controlled by another lever, adjustable, if desired, while the machine is running. The purpose of the pilot valve is to provide a controlling means that will give the delayed action required by the main valve. This always presents full openings during the table movement, up or down, and the ample lap on the ports gives time for expansion in the jarring cylinder, under light or medium loads, after the air supply has been cut off. Under approximately full loads there can be no appreciable expansion in the jarring cylinder. These patent shockless jarring machines are made by the Tabor Mfg. Co., Philadelphia. They are constructed in various designs and for different conditions. The tables, for the different machines, range from about 1 foot up to 6 feet square.

In Figs. 6, 7 and 8 have been shown different types of machines, having only the jolting action. In Figs. 9 and 10 are illustrated features that are added to the mere jolt ramming of molds. The great advantages gained by machine packing of sand would naturally cause engineers and founders to seek for means whereby, after the ramming of a mold, it could be rolled over and the pattern be drawn by mechanical methods. This achievement has been accomplished in various ways, especially in the making of small or lightweight castings.

It is only within the past two or three years that attempts have been made to embody the three features, ram, roll-over and draw, for making molds for medium and heavy castings. Progress has been made very recently in increasing the speed of operation of such machines. The machines shown in Figs. 9 and 10 are recent ones intended for medium-weight and heavy work. The type of machine seen in Figs. 9 and 10 is operated by electricity. Its builder, the Osborn Mfg. Co., Cleveland, has simply applied electric motors to its air-operated machine. Both the air and electrically-operated machines have the mold rolled over on its own center of gravity, the operation requiring very little power. In operating these machines, the mold board and pattern, *A* and *B*, Fig. 9 are secured to a holding or turn-over plate *C*, which is turned by power, to rest it on the jolting table *D*. The illustration shows the mold board and pattern being turned over, after the latter has been withdrawn from the mold *H*, to be seated again on the jolting table *D*. After the plate *C* has come to rest on the table *D*, the flask *E*, being turned upside down, is set on over the pattern *B* and is then filled with sand. This sand having been jolted and its excess struck off, the bottom board *F* is bedded on in place. This work is followed by clamping the bottom board and flask to the turning plate *C* and then turning them all over together, after which the truck *G* is run *under* the flask to receive it, as shown in Fig. 10. The pattern *B* having been drawn from the mold *H* as shown, the truck G is then run out on the rails *I*, as in Fig. 9, to come under a crane, which can convey the mold to any part of the shop. In the making of small molds, this conveyance can, of course, be done by hand. The lower part of the machine sets in an enclosed pit.

(To be concluded.)



DETAILS OF THREE-WHEEL ARBOR FOR PATTERNMAKERS

A Patternmaker's Arbor

By S. L. Cook

The description of a practical emery grinder for patternmakers, published in the August issue of *The Foundry*, recalls by its similarity an arbor which the writer has used for several years and which may be of interest. This arbor includes a flat wheel 6 inches in diameter and ½-inch face width, for grinding chisels and plane irons; a round-faced wheel, 6 inches in diameter and of ⅜-inch face width for gouge sharpening and a rag wheel for honing gouges. In using the rag wheel, the tool edge should, of course, be in a position opposite to that of grinding, and a piece of lump crocus or tripoli polishing compound should be rubbed on the wheel as it revolves. Though by no means an innovation, the use of the rag wheel is not as universal as it deserves to be.

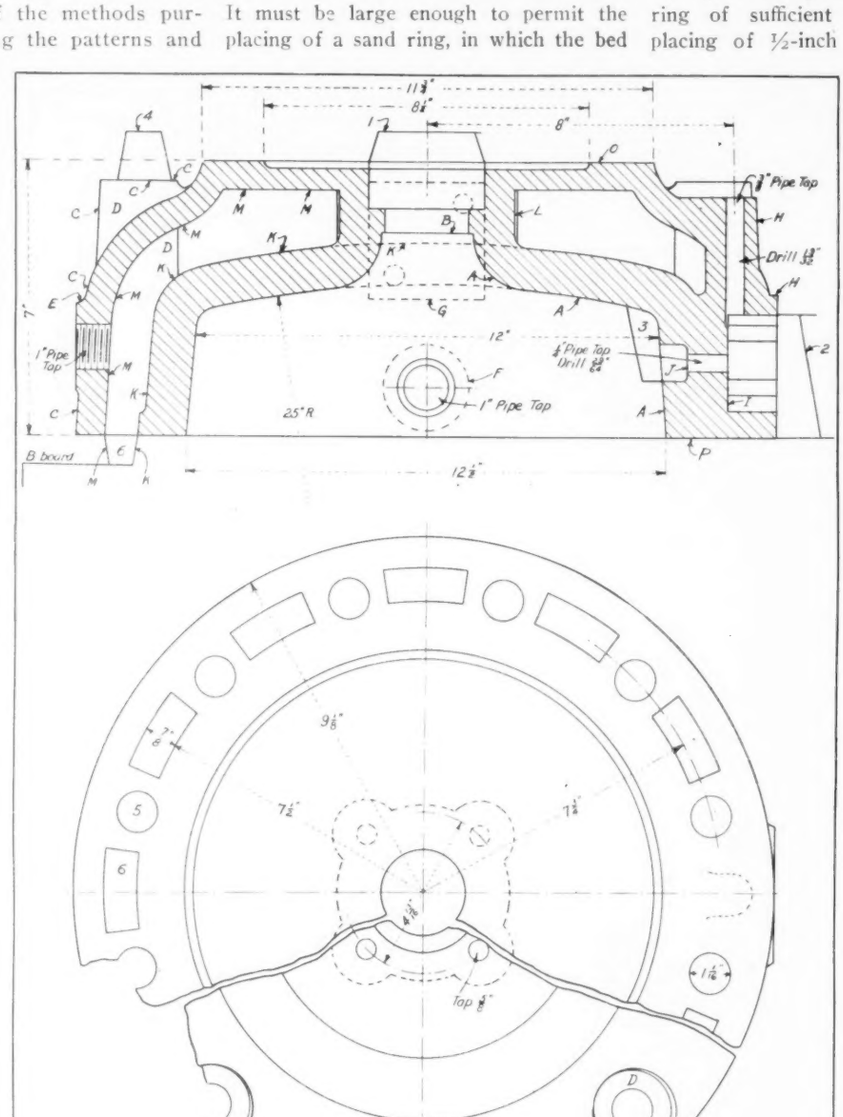
In the accompanying illustration, the device assembled is shown in *A*. In this case the parts were turned from maple and provided with a double coat of orange shellac varnish. *B* shows the details of construction, the slots being cut at right angles on a circular saw before the block is turned. It is necessary to keep the surface of such an arbor free from steel particles. The presence of the particles would cause the wheel to burn the tools instead of grinding them.

Notwithstanding the destruction by fire of its erecting and pattern shops, the Weimer Machine Works Co., Lebanon, Pa., has made arrangements for building its patterns at other local plants and all of the company's machinists are employed in the machine shop which was not damaged by fire. With the exception of the large work on the company's books, it is in position to make reasonable deliveries, owing to the fact that the smaller and medium size tools were not damaged in the fire.

Making a Cylinder Head Pattern

By E. W. Wallbank

While no particular novelty attaches to the construction of patterns for gas engine cylinder heads, many foundrymen who are not familiar with this class of work may be interested in a description of the methods pursued in constructing the patterns and molding these castings. The first step, of course, is the laying out of the plans, including all core prints and necessary finish, for which a layout board of ample size is procured, dimensions being made full-size. The accompanying illustration indicates the appearance of the casting when molded. The pattern is glued up in segments, the inside, along the line *A*, being turned out up to line *B*, so as to leave its own core. From *B* to the top, the pattern is built-in solid. A core print, *L*, is placed in position and a core box is made, down to line *B*. The outside of the pattern is turned up along the line *C* and bosses, *D*, are carved out of the pattern to insure accuracy.



PLAN OF CASTING FOR GAS ENGINE CYLINDER HEAD

Bosses *E*, *F* and *G* are placed in their respective positions and left loose. The bosses *H* are put on solid, a core print, *2*, extending to the bottom face of the pattern. Plenty of draft is necessary on this print, in order to secure a clean lift. A core box is made to core out the space, as shown, to line *I*. Core print *3* is located and a core box is made to line *J*. This core print also is a tail print. Core-prints *4* are placed solid on top of bosses *D*, plenty of draft also being required on these prints. Core prints *5* are relative to those at *4* and are placed directly below them. Core prints *6*, whose purpose is to locate the water jacket core, are situated between core prints *5*. As the water jacket core must conform to the periphery of the pattern, it also is glued up in segments. A bottom board is planed up true, sufficient battens having been glued and screwed on its under side. It must be large enough to permit the placing of a sand ring, in which the bed on which to dry the core, is made. After the bottom board is trued and the necessary centers and center lines are laid out upon it, the body is screwed on a face plate and turned up along line *K*, after which it is permanently secured to the bottom board. Now the bosses *D*, which continue in the water jacket, are carved out and set in their respective locations upon the body. The pad, *L*, next is placed centrally upon the body and left loose, with brass dowels, plug dowels being preferred. A hardwood sweep is made along line *M*, and the male half of a plate dowel is inserted to coincide with the female half located centrally in pad *L*. Bosses *D* are trimmed down so that the sweep will pass freely over them. A sand ring of sufficient size to permit the placing of ½-inch to ¾-inch of heap sand between it and the core is then turned. After the core is dried this superfluous sand is brushed off, its purpose being merely to supply a bed on which to dry the core. A round core box is made from the top of core prints *4* to the bottom of core prints *5*, in order to core the bolt holes through bosses *D*. These castings are made with face *O* in the cope and face *P* in the drag, the drag extending up the inside along line *A* to line *B*, and the cope extends down line *C* to face *P*. This method insures clean iron on the joint face of the cylinder head.

According to figures compiled by the American Iron and Steel Institute, the production of foundry iron during the first half of this year totaled 2,207,375 tons, as compared with 2,454,540 tons during the first six months of last year. The malleable iron production aggregated 278,512 tons, as compared with 383,139 tons the first half of 1914. The total pig iron production aggregated 12,233,791 tons, whereas during the first six months of last year it amounted to 12,536,094 tons. The production in Canada the first half of 1915 totaled 366,825 tons, as compared with a production of 442,430 tons during the first six months of the preceding year.

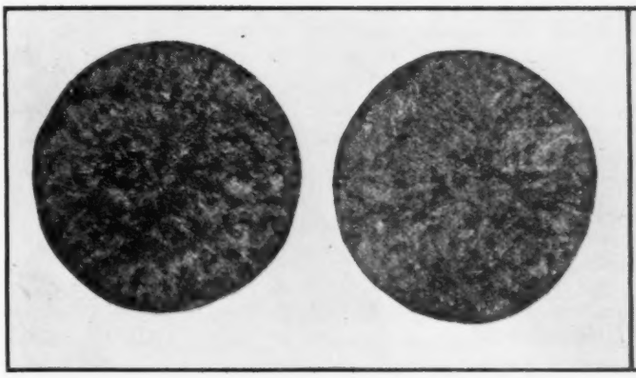


Fig. 1—Cast Iron Test Plug Showing Low-Mottled and Mottled Fractures

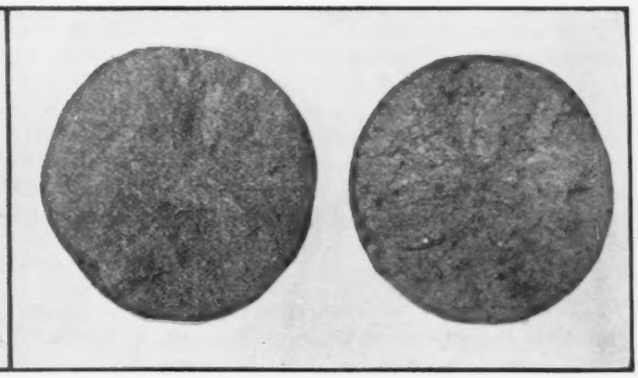


Fig. 2—Cast Iron Test Plug Showing High Mottled and White Fractures

Method for Controlling the Chill in Cast Iron

Results of Tests Showing the Relative Importance of Various Elements in Determining the Degree of Chill Obtained

By Grafton M Thrasher

SEVERAL years ago, while I was chief chemist of a malleable iron foundry, it occurred to me that the mere regulation of silicon was not sufficient to produce the desired degree of chill. But only after repeatedly encountering this fact in both open hearth and air furnace, as well as cupola metal, was I led to regard variation in the total carbon as the principal cause of disturbance; and I resolved to determine the total carbon as well as the silicon in every heat, and by a carefully prepared test piece to gage the approximate degree of chill. The test piece selected was a round plug, 2 inches in diameter and 12 inches long, cast on end in green sand. It was allowed to cool at least two hours in the mold before being cooled in water and broken in the middle; and the fractures were designated as gray, low mottled, mottled, high mottled, and white. All these fractures except the well-known gray one, are illustrated in Figs. 1 and 2. From the same ladle of iron from which the test piece was poured a shot sample was taken for analysis so as to represent the actual iron in the bar as near as possible; and the test in all cases was poured from iron taken from the furnace when about half emptied.

The author of this paper, which is to be presented at the February, 1916, meeting of the American Institute of Mining Engineers, is chief chemist and metallurgist of the Haskell & Barker Car Co., Michigan City, Ind.

Variations Plotted

It may be well to mention here that the principal disturbing influence on these tests is the fact (proved by experiment) that it is entirely possible to pour a mottled test and a gray test from the same ladle of iron, depending upon the pouring temperature.

In order to study the cause of the variations more systematically a chart was prepared for plotting the analyses with carbon as ordinates and silicon as abscissæ. It soon became apparent that the analyses corresponding to the test piece with average chill, designated as *mottled*, were arranged along a diagonal line on the chart with analyses corresponding to high and low chill at a more or less definite distance on either side of the line. It happened that about that time a heat had to be held pretty long in the furnace on account of a breakdown, and it became necessary to doctor it up with 50 per cent ferro-silicon to get the metal into pouring condition. The test piece from this heat was found to be just normal or what is designated above as *mottled*, and the corresponding

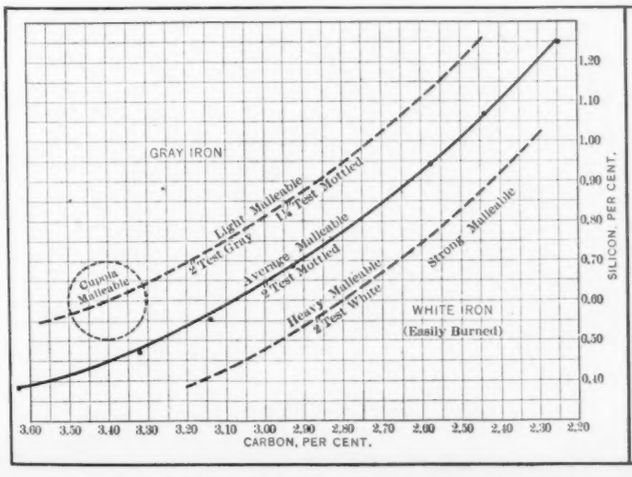


FIG. 3—LINES OF EQUAL NATURAL CHILL

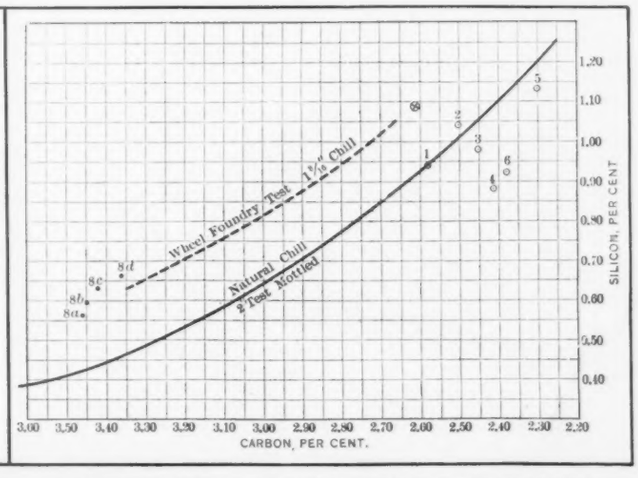


FIG. 4—ANALYSES OF BARS TESTED FOR TENSILE STRENGTH

analysis was silicon 1.07 and carbon 2.47 per cent, which served admirably for one extreme of the chill as drawn on the chart. Something to represent the other extreme was found in a pig of

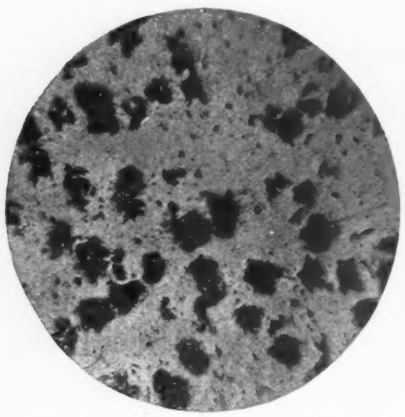


FIG. 5—STRUCTURE OF BAR NO. 1
Magnified 50 diameters

charcoal iron of the same dimensions as the test piece and having the proper degree of chill.

More recently I have obtained data for a new high-silicon point in which the analysis was, silicon 1.25, carbon 2.25 per cent. The chart as finally constructed is shown in Fig. 3.

As the manganese in all of these heats ranged between 0.25 and 0.35 per cent, which is normal for air-furnace malleable, and as sulphur averaged about 0.06 per cent, it will be seen that these elements interfered but little with the results. The phosphorus, of course, was between 0.13 and 0.18 per cent, and likewise had very little influence.

In examining the chart it will be noted that while the line tends to curve somewhat, yet it is sufficiently straight through the usual range of analyses to permit the assumption for practical purposes that four points of carbon are equivalent to three points of silicon in the regulation of chill, when the silicon is above 0.70 per cent; and that below this about two points carbon are equivalent to one point silicon.

The value of this knowledge will be at once apparent to a malleable iron foundryman, as it enables him to substitute large quantities of low-carbon material for his sprue in case of shortage of that material, thus:

It is desired to substitute steel containing silicon 0.10 and carbon 0.30 per cent for 1,000 pounds of sprue containing silicon 0.80 and carbon 2.80 per cent.

	Pounds.
Equivalent deficiency of silicon in the steel due to low carbon = (2.80 — 0.30) × ¾ × 1,000 =	18.7
Silicon deficiency = (0.80 — 0.10 × 1,000 =	7.0
Total equivalent silicon deficiency...	25.7

Therefore, it is necessary to increase the silicon in the mixture 25.7 pounds by substituting higher-silicon pig iron. The popular conception of malleable iron accepts the limits of 0.60 to 0.90 per cent in silicon, with a very indefinite notion as to what the carbon content in the hard state should be; but a careful examination of this chart will show that for a given silicon percentage there is a definite carbon percentage, which is proper for each class of castings.

Attainment of Malleability

In order to prevent cracked work and for other economic reasons, the malleable iron foundryman runs his mixture as nearly gray as he dares, but if he desires to produce a very strong iron the presence of primary graphite in the hard iron must be avoided by lowering either the silicon or the carbon or both. As to malleable iron produced with the same average chill but with varying analyses, it will be found that the high-

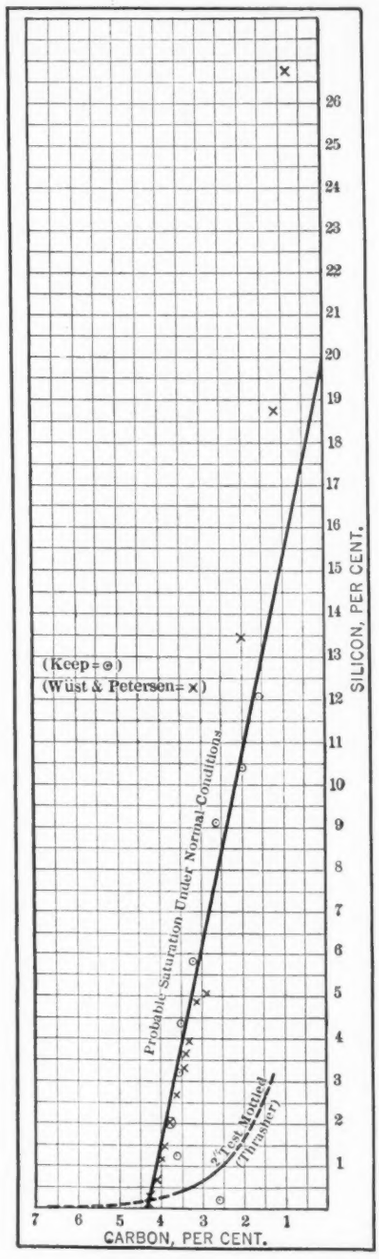


FIG. 6—RELATION OF LINE OF NATURAL CHILL TO THAT OF SATURATION

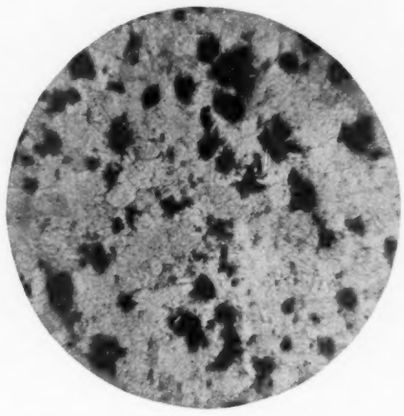


FIG. 7—STRUCTURE OF BAR NO. 4
Magnified 50 diameters

silicon, low-carbon mixture is more sound and reliable, but possibly a little less fluid, while the high-carbon, low-silicon mixture is subject to greater shrinkage and segregation, which produce weakness.

The principal consideration for the foundryman is to produce that type of structure which is necessary to obtain malleability upon annealing; and the chart shows the proper adjustment of silicon and carbon to bring about this desired result for the different grades of work.

It will be further noted that, of the three factors considered, namely, silicon and carbon content, and chill, if any two be known the other may be predicted approximately.

Malleable iron produced from the cupola is pretty well confined to the dotted circle shown on the chart. Its proximity to gray iron, as well as its position in the field of greater shrinkage, will account for its weakness, which is not due as popularly supposed to the higher sulphur content. As the carbon is automatically adjusted within this range by melting in the cupola, the regulation of chill must be effected by silicon alone. It is not feasible, however, to run a mixture lower than 0.50 per cent silicon because the cutting action of the slag thus produced is very hard in cupola linings. Good malleable castings are produced along the whole length of the charted lines; but the average foundryman, with his limited knowledge of conditions to be met in another foundry, cannot see how the other party makes a certain casting with 0.90 silicon while he finds it necessary to make it with 0.60 silicon. It is hoped that the publication of this chart will clarify the matter. The lines here given have been confirmed by plotting

hundreds of analyses of mixtures of known chill and normal pouring temperature and the chart has been found a valuable aid in practical work.

Regarding the strength of malleable iron produced from irons of varying degree of chill, the following data, charted in Fig. 4, from test bars poured every other day for two weeks, will give a good idea of the effect of this factor:

Bar No.	Tensile strength, lbs. per sq. in.	Elongation, per cent.	Silicon, per cent.	Carbon, per cent.
1	43,680	10.0	0.94	2.58
2	44,770	9.5	1.04	2.50
3	48,340	10.5	0.98	2.45
4	49,710	13.0	0.88	2.41
5	49,440	12.0	1.03	2.30
6	48,080	11.0	0.92	2.38

These test bars were round, 0.8 inch in diameter for 2 inches in the middle, and enlarged at the ends for gripping. A shrink ball was cast on one end to insure soundness. The structure of two of these bars is shown in Figs. 5 and 7. No. 1 the weaker bar, shows slight inclination to graphitic structure in the shape of the carbon particles.

The nearest approach that I have noticed to the co-ordination of such valuable facts as are above outlined is the paper published in the *Proceedings of the American Foundrymen's Association*, a couple of years ago, by John Jermain Porter, in which he plotted silicon and combined carbon; but as he made no statement as to the size of the castings from which these results were obtained, it is probable that this factor was not kept constant, which of course would account for a great many irregularities. Also, no reference was made to the effect of the total carbon on the combined-carbon content, which is highly important.

For the purpose of comparing the *natural chill* with that produced when cast iron is poured against an iron chiller, a test was made which conformed to that used in a car wheel foundry, using the same pattern and chill box. A ladle of very hot low-carbon iron was treated with sufficient 50 per cent ferro-silicon, as calculated from the chart, to produce the same degree of chill as that of the iron used in car wheels. It was necessary to allow the metal to cool for several minutes in the ladle before pouring, in order that the temperature should approximate that of practice in the wheel foundry, where the metal is not so hot when melted. The result of this experiment is chartered in Fig. 4 as No. 7, while a regular test piece from a wheel mixture showing the same degree of chill (1 8/16 inches) is charted as No. 8. The significance of this experiment is that it points the way to the production of car wheels with high silicon, low carbon, and low sulphur by the use of an open hearth furnace for melting. The rapidly increasing sulphur in the cast iron car wheel of today, due to the remelting of old wheels, is a source of anxiety to both the manufacturer and the railroad. The percentage of cementite in the structure of such a metal would still be sufficient to insure good wearing qualities and a higher percentage of silicon would insure soundness. The absence of large quantities of manganese sulphide, which is undoubtedly the cause of a large percentage of the defects in the tread, would be a strong argument in favor of such a metal.

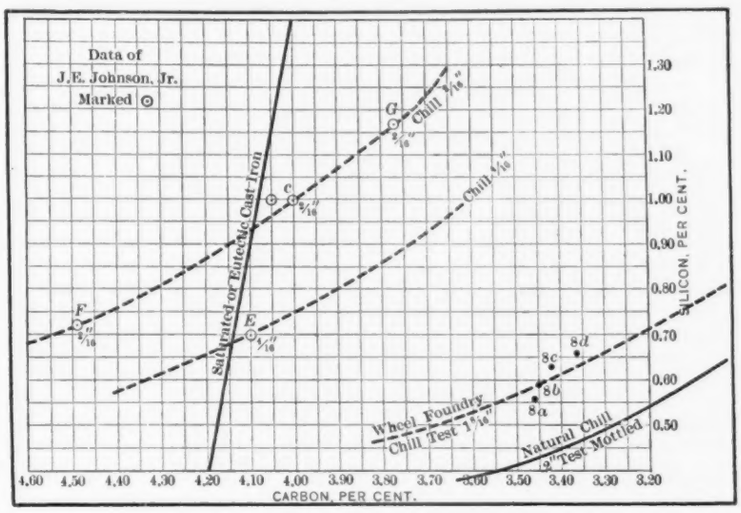

Data of
J.E. Johnson, Jr.
Marked ⊙
Saturated or Eutectic Cast Iron
Chill 5/16"
Chill 5/16"
Wheel Foundry
Chill Test 1 8/16"
Natural Chill
2" Test Mottled
SILICON, PER CENT.
CARBON, PER CENT.
4.60 4.50 4.40 4.30 4.20 4.10 4.00 3.90 3.80 3.70 3.60 3.50 3.40 3.30 3.20
1.30 1.20 1.10 1.00 0.90 0.80 0.70 0.60 0.50

FIG. 8—DATA OF J. E. JOHNSON JR.

It may be profitable to consider here the relationship of the *lines of natural chill* as described to the line of saturation of silicon and carbon in cast irons. For this purpose I have prepared another chart, Fig. 6, which outlines this relationship. The saturation figures are taken from Keep's *Cast Iron*, p. 45, and from the work of Wust and Petersen, as outlined by Hadfield. The line I produced, which is that of *natural chill*, is the same as that marked *2 Test Mottled* in Fig. 3. As a speculation it has been extended toward 6.67 carbon, as its probable trend in that direction, and upward to 3.50 silicon and 1.25 carbon, where it most probably tapers off and disappears due to the absence of carbon in sufficient excess of the pearlitic ratio to form graphite, which is necessary to produce the mottled fracture described.

It may be well to add a word concerning the influence of the other elements necessarily present in commercial irons which has been disregarded in this paper.

The effects of manganese and sulphur must be considered together, since it has been shown by several eminent investigators, that where present together in the proper ratio, they exist as MnS which, properly distributed, would be neutral and ineffective upon the chill or strength of the metal. In practical work it is found necessary to carry an excess of manganese above this ratio, to insure reliable metal. In cupola-melted irons where the carbon is high, an excess of from 0.05 to 0.10 per cent of manganese is sufficient, while iron melted in the air furnace or open-hearth requires from 0.10 to 0.30 per cent excess on account of greater exposure to oxidizing influences. It will be seen that where iron is properly melted to a fluid condition, the sulphur is fixed and without influence on chill, etc. If the 0.30 per cent excess manganese is figured to Mn_3C it will be apparent that it can affect only 0.02 per cent of carbon, which would have but small influence on the chill.

In my opinion the effect of sulphur on the chill, even when present uncombined with manganese, has been greatly exaggerated, and that oxygen occurring simultaneously will be found responsible for this exaggeration. Regarding the effect of phosphorus on the chill, it will be sufficient to cite Hadfield, who says, in discussing Stead's work on this element:

"Since, however, there is seldom more than 1.5 per cent of phosphorus present in pig irons used in foundry work, it may be considered that the influence of such percentages upon the condition of the carbon is negligible".

It will be seen that in the control of chill in malleable iron and car-wheel mixtures, where this element does not exceed one-fifth of 1.5 per cent its effect cannot be noticed.

Though I have not made an independent investigation of the effect of oxygen on the chill, I am inclined to believe from the data at hand that its effect is mainly qualitative rather than quantitative. While I fail to agree with some of the conclusions of J. E. Johnson Jr., I think his theory of the existence of an oxy-sulphide is true. In

(*Continued on page* 512.)

Spelter Impurity in Slush Castings

By Gilbert Rigg and Henry C Morse

THE PROCESS of slush casting is used extensively in the manufacture of various ornamental objects. Hollow, and, therefore, relatively light castings are produced. The molds used are metal, usually bronze or brass, which can be machined evenly and which will not be injured in pouring. Faithful reproductions of intricate designs can be obtained by this means. But it is necessary to secure a metal for casting purposes which melts at a relatively low temperature into a mobile liquid, and which will not crack and pull apart under cooling stresses.

The slush casting process may be briefly described as follows: The metal is poured into the mold until it is full, then immediately withdrawn from it, leaving a thin-walled casting chilled upon the inside surface. The mold is usually mounted upon trunnions or otherwise arranged to facilitate its rapid emptying. Because of their extensive use for ornamental purposes, slush castings are often plated, stained or treated in other ways to produce color effects. Therefore, other properties are required besides that of perfection of surface and accurate reproduction of pattern. The surface must not only be a smooth and faithful representation of the mold, but must also be free from any microscopically small cracks or pin holes. A large flaw, which can be readily seen can be removed by chipping and filling with solder, or the casting can be immediately rejected and remelted, but a small one may escape a careful inspection. Flaws of this kind tend to take up and hold some of the liquor from the plating solutions, causing a stain to appear later. Hence, for good work, it is necessary to use a metal which will give castings entirely free from cracks or flaws of any kind.

A paper read at the annual meeting of the American Institute of Metals, Sept. 28 to Oct. 1, Atlantic City, N. J.

Conditions of Operation

For economical results, certain conditions must be borne in mind and applied, referring both to the metal used and to the casting practice. The production of as light castings as possible, consistent with strength, makes for economy in metal. A metal should be used which is subject to minimum losses by oxidation, drossing, etc., while standing molten in the pot. The production of as large a percentage of perfect castings as possible is desirable, thus cutting down loss of time and labor. These three factors interfere, to a certain extent. Economy in the use of metal or the use of as little as possible in each casting can be obtained only with a metal possessing a small solidification range and a high fluidity at the time of casting. A high casting temperature will aid this. Economy of metal, as regards loss by oxidation at the surface, is obtained only by a low casting temperature and the least possible manipulation of the bath. This conflict between high and low casting temperatures, as required by the first and second conditions, can only be harmonized in the light of experience in order to arrive at a happy medium. Economy of time depends upon the employment of a reliable metal, giving uniformly dependable results, and upon the experience of the persons handling the process, together with the strictest attention to the control of the operating conditions. The constant use of a thermo-couple and galvanometer should replace temperature judging by eye. The remaining conditions making for a good behavior of the bath can best be taken up later as we discuss the behavior of the various forms of impurities found in spelter.

The common impurities of spelter

FIG. 1—SECTION OF SLUSH CASTING CONTAINING 0.2 PER CENT CADMIUM

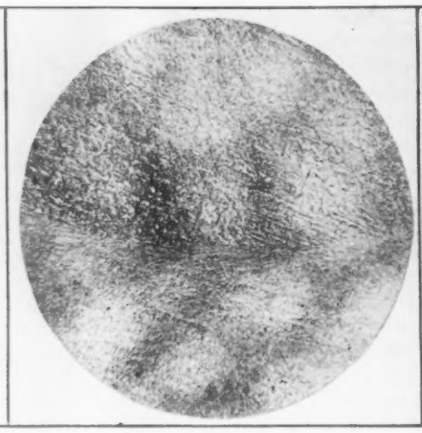


FIG. 2 — SPELTER SLAB CONTAINING CADMIUM

FIG. 3—SLOWLY COOLED SPELTER CONTAINING CADMIUM

are cadmium, lead, iron and arsenic. The American Society for Testing Materials has classified spelter into four grades, depending upon the amount of impurity present. High

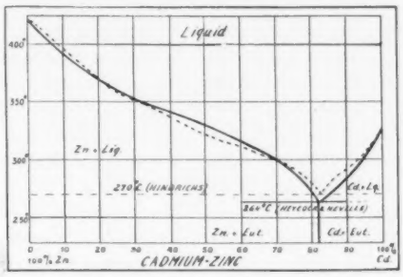


FIG. 4—THERMAL DIAGRAM OF CADMIUM-ZINC SYSTEM

grade, it is specified, shall not contain over 0.05 per cent cadmium, 0.07 per cent lead and 0.03 per cent iron. The sum of these impurities shall not exceed 0.1 per cent. Intermediate grade shall not contain over 0.5 per cent cadmium, 0.2 per cent lead and 0.03 per cent iron. The sum of these impurities shall not exceed 0.5 per cent. Brass special spelter shall not contain over 0.75 per cent cadmium, 0.75 per cent lead and 0.04 per cent iron. The sum of these impurities shall not exceed 1.2 per cent. No aluminum is allowed in any of the foregoing spelters. Common or prime western spelter shall not contain over 1.5 per cent lead and 0.08 per cent iron. Arsenic is not mentioned, as it occurs only in the most impure spelters and usually in very small amounts. These impurities differ greatly among themselves in the manner of their combination with zinc; and the alloys formed show very different behaviors. Cadmium and zinc form a series of simple eutectiferous nature possessing mutual solubility in the liquid state, but mutual insolubility in the solid. Fig. 4 shows an equilibrium diagram of the series as compiled by Arnemann. Hindricks has described the series as being of such a nature that below the liquidus curve at the zinc-rich end of the series, the metal consists of solid crystals of zinc separating from a liquid solution of the two metals, and below the solidus curve, of solid crystals of zinc in a matrix of eutectic. Fig. 1 is a section of a slush casting containing 0.2 per cent cadmium. The blurred or mottled appearance of the zinc grains is characteristic of these alloys when suddenly cooled. Fig. 2 illustrates a section of impure spelter in slab form, with the same structure developed upon the coarse crystals. This appearance is due to slight cadmium segregations which have started in the liquid during cooling, but which the rapid rate of cooling halted before their completion. The result is a solid solution of cadmium in zinc of unequal strength, in different areas. Upon polishing and etching with dilute nitric acid, the areas richer in cadmium become covered with a thin film of brown cadmium oxide. But the mottled structure characteristc of cadmium in these comparatively quickly cooled sections also shows the extent to which the conditions of working have induced conditions in the metal different from those of equilibrium. In these sections we can pick out no actual interstitial segregation of cadmium-zinc alloy between grains of pure zinc. Freezing has been so rapid that the dissolved condition of the cadmium in the liquid zinc has been preserved in the solid. Fig. 3 is a section of an extremely slowly cooled cadmium-bearing spelter containing 0.6 per cent cadmium, and Fig. 6 shows the same alloy rapidly cooled. The former section shows a bright band of cadmium-zinc alloy lying along the boundary between two zinc grains, from which it was forced during the period of cooling; while the latter shows the boundaries between the grains as sharp lines without the presence of interstitial matter, the cadmium content being indicated by the mottling of the zinc grains. The rapidly cooled alloy of zinc and cadmium as it occurs in a slush casting

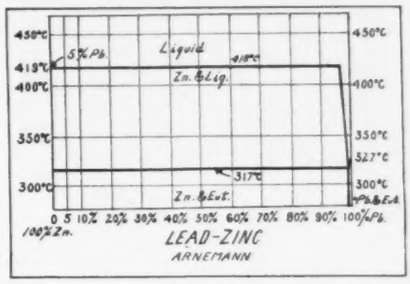


FIG. 5—THERMAL DIAGRAM OF LEAD-ZINC SYSTEM (ARNEMANN)

behaves very differently from pure zinc, as will be shown later.

Mixtures of lead and zinc give alloys differing radically from these instances. Fig. 5 illustrates the lead-zinc equilibrium diagram of Arnemann. A slight reduction of the melting point is noted with the addition of 0.5 per cent lead, but except for this, and for the eutectic mixture at the extreme lead-rich end of the series, the two are immiscible. The following solubilities were determined by analysis of the two layers of liquid at different temperatures:

	Lower layer.		Upper layer.	
Temp., degrees, Cent.	Per cent, Pb.	Per cent, Zn.	Per cent, Pb.	Per cent, Zn.
334	98.8	1.2	...	....
419	....	....	1.5	98.5
450	92.0	8.0	...	....
475	91.0	9.0	2.0	98.0
514	89.0	11.0	3.0	97.0
584	86.0	14.0	5.0	95.0
650	83.0	17.0	7.0	93.0
740	79.0	21.0	10.0	90.0
800	75.0	25.0	14.0	86.0
900	59.0	41.0	25.5	74.5

At temperatures not far from the boiling point of zinc, 960 degrees Cent., these experimenters have determined the presence of two layers, in the upper of which 25.5 per cent of lead can be held in solution by the zinc. On cooling, the lead separ-

FIG. 6—QUICKLY COOLED CADMIUM-BEARING SPELTER

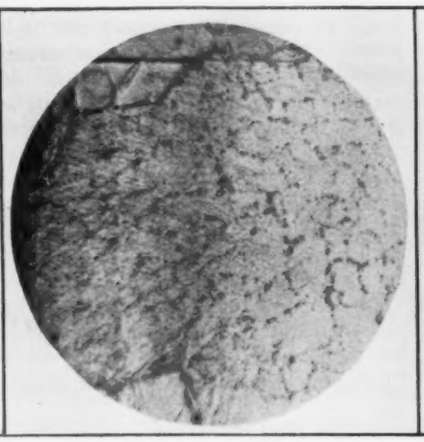


FIG. 7—LEAD-BEARING SLUSH CASTING

FIG. 8—SECTION OF IRON-BEARING DROSS SLAB

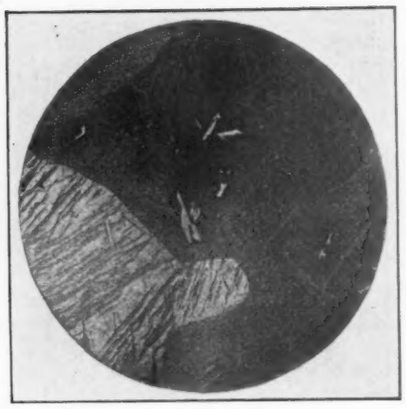


FIG. 9—IRON-BEARING SLUSH CASTING

ates to a greater extent and the two layers differ more widely in composition, the lead by reason of its higher density going to the bottom. This separation, however, is never complete. Practically, a lead content of 1 per cent is retained by the zinc after liquation.

The microscope shows that we are not dealing with a solution, but with a suspension. The small globules of lead can be easily detected in the zinc ground mass. It is evident that at the temperature of solidification of the zinc, the lead is still liquid. It is, therefore, forced to a position between the zinc grains and remains liquid through a considerable part of the time of cooling. A fall of 91 degrees Cent. must take place after the freezing of the zinc, before the solidification of the lead occurs. After the solidification has become complete, the lead, by its soft and yielding nature, may still act as a lubricant to some extent, though there is no evidence of this in practice. Fig. 7 illustrates a section of a casting containing 0.5 per cent lead.

Iron combines with zinc to form crystals after a definite and well-known manner. A reproduction of the zinc-rich end of the thermal diagram of the system appears in Fig. 12. Many investigators have studied this series of alloys in connection with the galvanizing industry, and have proved that the action between the two metals is of the nature of a chemical combination. Crystals having approximately the composition FeZn are formed, which are of greater specific gravity than the zinc and therefore tend to settle to the bottom of the melt, though iron cannot be completely separated from zinc in this manner. Fig. 8 shows a section of a dross slab containing 2.54 per cent iron, in which the characteristic occurrences of these crystals can be noted. Fig. 9 is a section of a slush casting containing 0.092 per cent iron and Fig. 11 of one containing 0.18 per cent iron. The melting point of these crystals is high and the steep slope of the liquidus curve in the lower ranges of the diagram shows how certain is the presence of these solid crystalline bodies in the liquid bath when the total iron content is high. Their occurrence in the alloys shows also the fact of their having been present as solids during the cooling, when the zinc was still liquid. Two structural elements are therefore present in these suddenly cooled alloys; solid angular crystals of iron-zinc alloy, around which has solidified a mass of zinc crystals. From these considerations, the real nature of the alloy can be easily understood. As long as the alloy crystals are not present in great enough amount to force their own properties upon the metal as a whole, their effect upon the alloy is not large. Another effect which these iron alloy crystals have, along with any other solid phase which may be present in liquid zinc at the time of coloing, is a tendency to bring about a reduction in the size of the zinc crystals. Fairly large quantities of solid matter must be present to produce the effect, however, and it is not to be noticed in spelters containing iron in permissible quantities.

Arsenic combines with zinc in much the same way as iron. Fig. 14 is a reproduction of the curve of equilibrium of this series. As is the case with the iron-zinc diagram, the liquidus has been dotted as it approaches pure zinc, denoting some uncertainty as to the form in this region. As shown by the curve and by microscopic examination of alloys containing small amounts of arsenic, a crystalline constituent exists in the zinc at the time of freezing. This is said to be represented by the formula $As_2 Zn_3$. It is in the form of small irregularly shaped bodies, etching greenish, with dilute nitric acid. The volatility of arsenic at ordinary pressure is an important factor in connection with these alloys, even in the low range with which we have to deal. It is a factor which evidently affects the arsenic content of the alloy to a greater and greater degree as it stands molten. In this condition, a constant odor of subliming arsenic may be noted. In our experience these alloys differed widely from their computed composition as made up by diluting a rich alloy bar with pure spelter, indicating that a continuous volatilization of arsenic takes place. This tends only toward a purification of the bath as the operations progress; and the additional fact of the apparently very slight effect of this impurity upon the castings has made the subject of its presence one of minor importance in this class of work. Fig. 13 shows a section of an arsenic alloy casting containing 0.052 per cent arsenic. Fig. 15 represents a section of an alloy slab containing 0.5 per cent arsenic. We have taken up the case of the alloying of aluminum with zinc,

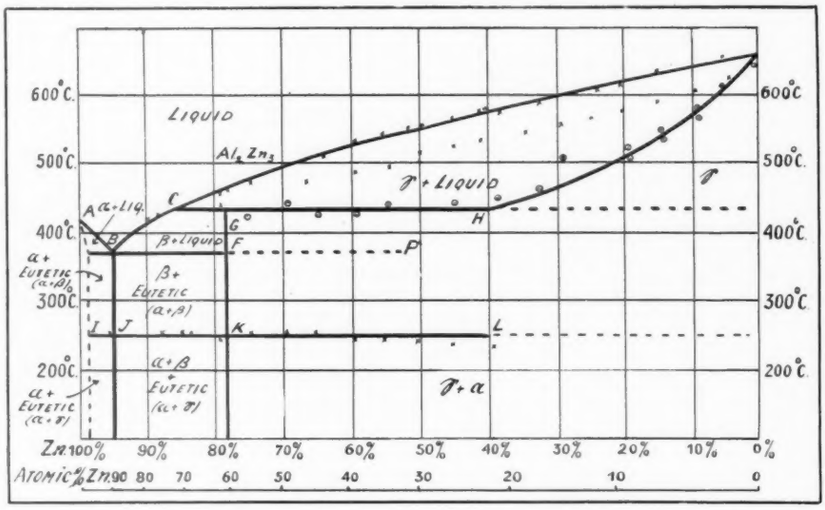


FIG. 10—ALUMINUM-ZINC SYSTEM DIAGRAM (ROSENHAIN-ARCHBUT)

FIG. 11—SLUSH CASTING CONTAINING IRON

though the metal does not occur as an impurity in virgin spelter and is expressly forbidden in the specifications of the American Society for Testing Materials for all grades but the prime western. The use of aluminum is not unusual in galvanizing practice and in general alloying work. Because of its well-known clearing action upon the galvanizing bath, not only in lessening scum formation upon the surface, but in increasing fluidity and, as claimed by Sang, in removing iron as crystals of the formula Al_3Fe, the possibility of its use for slush castings seemed worthy of investigation. Fig. 10 is a reproduction of an aluminum-zinc thermal diagram. It shows a simple eutectiferous series, solutions of the two being present in both the liquid and solid states. A reaction point, at approximately 17 per cent aluminum, is noted, as is also a metastable eutectic. Commencing with percentages of aluminum in the order of the occurrence of the impurities in spelter, and the general use of aluminum as a clearing agent in the galvanizing bath, amounting to small fractions of 1 per cent, we have tested the series up to an aluminum content of 5 per cent, which is the composition of the eutectic. At this point, exceedingly gratifying results were obtained by the use of aluminum and high grade spelter. Fig. 16 shows the appearance of this eutectic, containing 5 per cent aluminum and 95 per cent zinc, taken from a slab. The slush castings of this alloy, being more rapidly cooled, give a finer grained structure, which does not lend itself so well to reproduction as the more slowly cooled alloy.

The alloys were melted in a No. 45 graphite crucible, heated in a coke furnace with a positive blow, controlled by a valve, 80 to 90 pounds

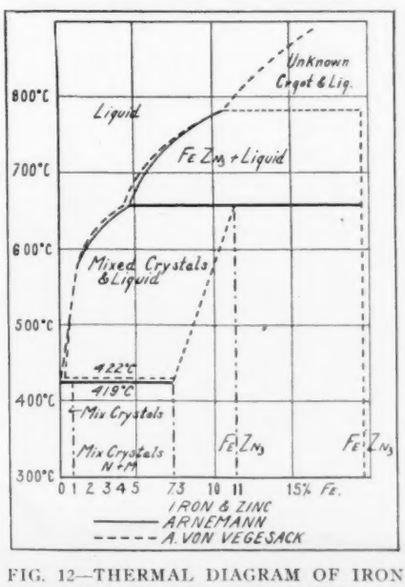


FIG. 12—THERMAL DIAGRAM OF IRON-ZINC SYSTEM (ARNEMANN)

of metal being used to a charge. Ladles for dipping the metal from the pot and pouring it into the mold, the mold itself, and a work bench supporting the mold by its trunnions and allowing its ready emptying, completed the apparatus. For temperature regulation we used a platinum, platinum-iridium thermo-couple connected with a galvanometer of the suspension type. The couple was protected from contact with the bath by a silica tube closed at the lower end and was dipped directly into the molten metal and supported so that the operation of ladling out and returning the metal to the pot could be carried out without disturbing it.

The mold was of bronze. Its appearance closed and open, together with examples of the castings, is shown in Figs. 17, 18 and 19. When closed, the two halves were held together by a pair of tongs with a link on the handles. The metal was poured into *A* until it rose in *B*, as shown

FIG. 13—ARSENICAL SLUSH CASTING

in Fig. 17, and was then immediately poured back into the ladle. The ladle and interior of the mold were coated with soot. The alloys were made up by adding the impurity to be studied to high grade spelter containing 99.95 per cent zinc. This first series of alloys had the following composition:

Cadmium-zinc alloy, 1.0 per cent cadmium.
Lead-zinc alloy, 1.0 per cent lead.
Iron-zinc alloy, 3.0 per cent iron.
Arsenic-zinc alloy, 0.5 per cent arsenic.
Aluminum-zinc alloy, 5.0 per cent aluminum.

These were checked by analysis and then diluted to the desired composition by the addition of spelter. In casting, the practice adopted was to advance from the more pure to the less pure metal. The pots used were cleaned as thoroughly as possible between tests by scraping so long as the same impurity was being tested; but in cases where a change of alloy was made, we cleaned the cold pots thoroughly with coarse sand paper and, if the occasion demanded, used an entirely new one. The qualities

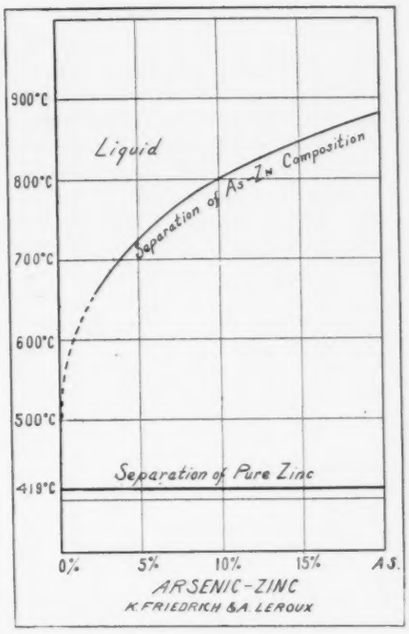


FIG. 14—THERMAL DIAGRAM OF ARSENIC-ZINC SYSTEM (ARNEMANN)

which go to make up a perfect casting metal may be summed up as follows:

The metal must yield castings free from cracks and flaws of any kind. Its surface must be smooth and bright. The weight must be low enough to be economical. The metal must not be too sensitive to variations of temperature at pouring.

It may be stated at once that there is no naturally occurring impurity in spelter, which tends to improve the metal in these respects. The purer the metal the better it behaves. A glance at the casting will show that its shape insures that it will be held at both ends by the mold as it solidifies and hence any serious tendency to hot shortness will certainly result in cracking. With anything like careful work, cracked castings do not occur with pure metal. The surface is finely crystalline and smooth. The weight will not exceed 850 grams per casting and average 750 grams. The dimensions of the mold are 22.5 centimeters in length by 6.5 centimeters at the largest diameter and 2.5 centimeters at the smallest. The thickness of the casting varies from 2 to 2.5 millimeters. Good castings can be obtained throughout a range of temperature from 430 degrees to 470 degrees Cent. Below this lower limit they are too heavy and above the upper one they tend to crack. Figs. 20 and 21 are sections of these castings. In these sections a banded or lined structure within the individual crystals is very prominently brought out. This structure has been developed in cast zinc, though not to

as great an extent, and was described as indicating the presence of slip planes within the crystals. Its extensive development in our sections which have been subjected to severe strains during cooling and after the solidification has been completed, is an indication of the truth of this explanation. The planes have evidently been the means of obtaining relief from strains, otherwise only obtained by cracking. This structure is very easily developed in cast zinc by shock and it is asserted that the operation of sawing and grinding a specimen for examination will frequently produce it. The two sections, however, illustrate the mechanics of the distribution and neutralization of stresses in pure zinc, and a comparison of these sections with the others illustrating this article indicates the extent to which this tendency to stretch is prevented by the presence of impurities in the metal. The mold naturally heats up during the operation. With some alloys this causes trouble and the rate at which good castings can be made is cut down in consequence.

Method of Procedure

In testing out the alloys it was necessary in each case to work out a technique which was as favorable as possible to good results, before taking records. Several castings were always made before starting a run, in order to establish the proper conditions. In considering the results that follow, it must be borne in mind that every care was taken to fit the practice to the alloy, and that while in the case of iron alloys, for example, a fair proportion of good castings was obtained, the working conditions were more delicate and more care was needed to get good results, than in the case of the high grade metal.

The tests indicated that cadmium produces the most serious effect upon spelter. The condition may be termed one of aggravated hot shortness. Appropriation of 0.05 per cent cadmium in the metal to be cast made it impossible to obtain any acceptable castings. This amount of cadmium can be readily detected by microscopic examination, not as a segregate from the zinc, but by the characteristic cloudy, spotted appearance of the zinc grains themselves. This structure is common to all and suggests that the crystallized product by rapid cooling has been held as a solid solution of cadmium in zinc entirely. The hot short condition persists through all of the cadmium alloys, irrespective of the presence of other metals. As far as perfection goes, no distinction can be made between the alloys of 0.05 per cent and 0.5 per cent cadmium content, but in appearance, both in the liquid and solid state, differences are to be noted. The metal is distinctly more fluid as the cadmium content increases and in a good deal greater degree than could be expected

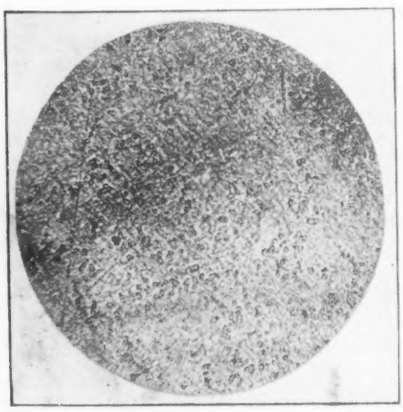


FIG. 15—SPELTER SLAB CONTAINING ARSENIC

FIG. 16—ALUMINUM-ZINC SLAB SECTION

from the slope of the liquidus curve of the thermal diagram. This phenomenon may possibly be explained as due to a tendency toward supercooling which the impurity in solution may produce. Cadmium in these quantities does not have any appreciable effect upon the formation of oxides upon the surface of the bath. The large loss of cadmium which we know takes place in brass-making, does not occur in this work, because of the low temperature involved. In appearance, the castings of cadmium-bearing spelters show a smoother and less crystalline surface than those of pure spelter. This may be explained by the fact that cadmium alters the general form of crystallization from that of relatively coarse texture to one of finer grain. We have experimented through all possible ranges of casting temperature and weight of casting regulated by the length of time the metal remained in the mold in order to test the possibility of obtaining perfect

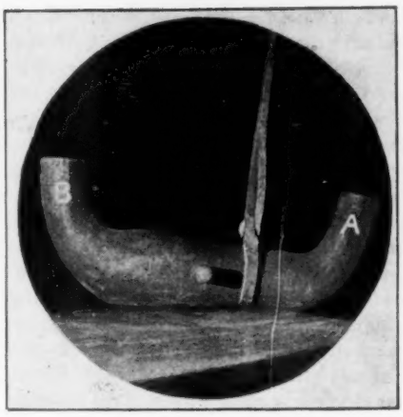


FIG. 17—SLUSH CASTING MOLD CLOSED

castings with these alloys, but have found the hot-short condition impossible to overcome. A temperature of 425 degrees, dangerously near the freezing point of the bath failed to give perfect objects and a weight of one kilogram failed likewise in giving enough strength to the metal to produce perfection. A cadmium content of 0.05 per cent appears to be just beyond the border on the useless side. This shows the allowable cadmium content to be very low.

Shape of Mold

Another test, giving results agreeing very closely with those of the slush casting tests, resembled the common hot shortness test of casting in a metal mold and object shaped as a flattened dumb-bell. A neck ¼ x ¼ x 2 inches connects two discs 2 inches in diameter by ¼-inch thick. High grade spelter can be cast successfully in this shape at temperatures from one as nearly freezing as the metal can be gotten into the mold, to a dull red heat. All spelters containing over 0.1 per cent cadmium failed by pulling apart in the neck when cast at the lowest possible temperatures. At a cadmium content of 0.05 per cent it was possible to cast perfect objects when using very low temperatures.

Lead in slush castings affects the results adversely in proportion to the percentage present. The general effect is weakening, due, as explained above, to the lead being still liquid at the temperature of solidification of the zinc. The decrease in tensile strength, due to the presence of liquid lead between two solid zinc grains which are being pulled apart by cooling stresses, may be somewhat neutralized by the lubricating action of the liquid when it lies in a direction along which slipping may occur. But the weakening effect preponderates. The fluidity of the metal is not affected by the presence of the lead,

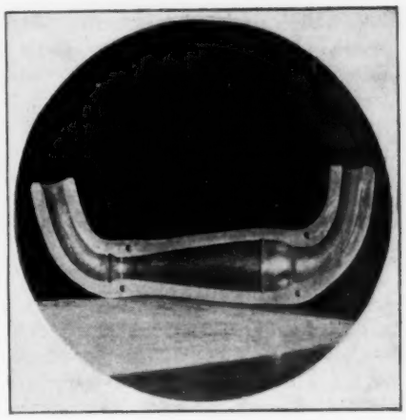


FIG. 18—HALF OF MOLD SHOWING INTERIOR

the casting temperatures running between 440 and 450 degrees Cent. By keeping the metal cool and allowing it to lie a little longer in the mold than is the practice with pure metal, a considerable proportion of castings free from cracks were obtained, but heavier than with pure metal, and, therefore, less economical. For percentages of lead below 0.2 per cent the results are good. Above this, the difficulties increase and in general for metal running between 0.2 per cent and 0.6 per cent of lead, the yield of uncracked castings averaged 50 per cent, and the weight from 800 to 900 grams, as against 100 per cent and 7,500 grams for the pure metal. With molds of less severity and careful working a fair practice could, no doubt, be worked up, but the presence of lead undoubtedly makes the metal sensitive. The results obtained with three alloys is as follows:

Per cent Pb.	Weight of castings in grams	Per cent perfect castings.
0.141	790	80
0.349	810	58
0.547	920	56

Lead does not affect the appearance of the castings. When both lead and cadmium are present the castings behave exactly like a straight cadmium-zinc alloy and no uncracked castings are obtainable. The influence of iron is decidedly erratic. The results are not concordant to any degree and the variations are erratic both in direction and amount, though conditions were carefully watched. The results of two runs on iron alloys are given below:

Percent acceptable castings....	55.5	38.4
Average wgt. perfect castings..	760	842
Average weight cast.....	750	808
Average pot temp.....	466	491
Wght. of lightest perfect casting	620	670
No. perfect under 850 gms.....	15	10
No. perfect	18	18
Total No. cast.....	27	26
Per cent iron.....	.045	.34

The general trend of conditions can be seen to be toward an increase of viscosity with increase of iron content. An increase of pot temperature was found to be necessary in order to partly compensate for this, though a rise in the weight of castings is noted to have taken place in spite of it. A corresponding fall in the percentage of acceptable castings has resulted. Variations in the yield of acceptable castings from 20 per cent to 70 per cent occur in the members of the series tested, containing from 0.045 to 0.58 per cent iron, and point to the fact of this sensitiveness being due more to the manner of distribution of the iron alloy crystals, than to the frequency of their occurrence. It may readily be imagined how a group of these small bodies segregated at a point in the casting might alter the even distribution of cooling stresses and cause cracks to appear. The higher casting temperature required with the higher iron alloys is naturally a matter contributing to their greater sensitiveness, as well as to a greater loss of metal by the increased amount of scum formed. The presence of iron has no effect upon the appearance of

FIG. 19—PERFECT AND CRACKED CASTINGS

the surface of the finished castings, though the higher casting temperatures used tend to produce greater smoothness.

Results with Arsenic Alloys

The results obtained with the arsenic alloys agree in kind with those of the iron series. Temperatures of castings are variable as the viscosity of the liquid tends to increase with arsenic content. Up to a percentage of 0.1 per cent, the results show arsenic to be practically without effect, the necessary increase of temperature not being great. But above this percentage, the thickening effect upon the bath is apparent and at amounts of 0.4 per cent and 0.5 per cent, it is so great as to make the metal unmanageable for this purpose. The volatility of arsenic is an important feature of the work, for with long standing or repeated melting the expulsion of arsenic by this means becomes considerable. For example, an alloy made up to give 0.2 per cent arsenic, failed of this amount by 64 per cent of the arsenic originally present. Other arsenic losses were proportionate. Below 0.07 per cent, the losses were of a much smaller order of magnitude and little difficulty was encountered in making up alloys which analyzed fairly close to the desired compositions. The variations in weights and percentages of acceptable castings obtained from arsenic alloys of the lower ranges vary considerably, but not in direct relation to the arsenic content. The results indicate that arsenic, when present in the amounts in which it is found in spelters, does not affect the results. As in the case of iron, arsenic does not affect the appearance of castings.

The results of the aluminum tests may be grouped here because of their interest, though aluminum is not an impurity of natural occurrence. These tests bring out strongly the advantage of working with metal which at solidification will display homogeneity of structure. This can be obtained in only two cases, that of a pure metal, and that of a pure eutectic solution. In the first case there is maximum fluidity, because the metal is free from solid phases which would tend to separate out before the freezing point of the whole has been reached. Also, in the second case the separation of a solid phase will not take place because of the definite freezing point at which the solution of a eutectic composition solidifies as a whole. A minimum freezing range is obtained. But a metal of eutectic composition has a possible advantage over a pure metal alone, which is brought out by the microscope in a study of the two. A pure metal crystallizes in polyhedral grains, all of approximately the same size and general structure. Owing to causes which are beyond the scope of the present article, a eutectic freezes differently. The general structure is granular, but within the grains, the freezing prog-

FIG. 20—SECTION OF CASTING—HIGH GRADE SPELTER

resses after a vibratory manner. Fig. 16 is a section of an aluminum-zinc eutectic alloy, cut from a slab, hence more slowly cooled than the metal of the slush castings, which illustrates this structure very clearly.

Immediately upon adding a small quantity of aluminum the characteristic clearing of the bath occurred. But instead of causing an increased fluidity of the bath, which would remain up to the point of solidification, the effect was to thicken the metal in the temperature ranges used. In other words, a mixture of longer freezing range had been obtained. This condition remained through the interval above extremely low aluminum values and below 5 per cent. At this latter content, the weight of castings became very low and the metal was not especially sensitive to temperature variations in casting. This test, made with pure spelter and an aluminum content of 5.3 per cent, gave what might be considered remarkable results. At an average casting temperature of 451 degrees Cent., perfect castings were produced, averaging in weight 468 grams, the results being extremely uniform and certain. The castings did not have the outside surface characteristic of those of pure metal, as crystallization was not as prominent, but this gave an opportunity for a very accurate reproduction of the mold surface upon the object.

Objections to Aluminum-Zinc Alloys

Serious objections have been raised to the use of the aluminum-zinc alloys, because of an alteration or decomposition to which they have frequently been subject. Such troubles have been attributed to the presence of the impurities carried into the alloy by the use of low grade spelter in its manufacture. Alloys made from the high grade zinc have given no difficulty. Several cases of this decomposition have come to our notice and in this connection we have experimented with a 20 per cent aluminum, 80 per cent zinc alloy to some extent. This alloy has been made up with commercial aluminum and low and high grade spelters and subjected to tests as follows:

Annealing in the ordinary atmosphere at 88 degrees Cent.; annealing in wet steam at atmospheric pressure; annealing at 260 degrees Cent. (above the reaction temperature) in a closed muffle furnace, and annealing at 150 degrees Cent. in a closed muffle furnace.

Annealing according to the first method, after the end of a month, has shown a distinctly greater tarnish upon the alloy of common spelter than upon that of high grade, with a very minute crack upon one of the inferior grade castings. The second method has shown at the end of one day very marked corrosion upon the surface of the common spelter casting. At the end of a week, the casting containing the inferior grade spelter had cracked, swollen and crumbled to such an extent that its failure was unmistakable. The casting containing high grade spelter, after the same treatment, showed a tarnish only, with no indication of a crack or other evidence of decomposition. The third method brought about a recrystallization in both cases, though in that of the low grade spelter alloy it was accompanied by cracking, while the high grade spelter alloy showed none. The fourth method proved to be merely a repetition of the first. With the exception of the 5 per cent alloy, the results have not been satisfactory. In percentages

FIG. 21—SECTION OF SLUSH CASTING —HIGH GRADE SPELTER

of aluminum less than this, the effect is to increase viscosity, owing to the separation of a solid phase while cooling.

The results obtained with these alloys and the increase in viscosity brought about by increase of aluminum content up to 5 per cent, as evidenced by the weight of the castings, followed by an abrupt drop in viscosity and weight at the eutectic composition, are shown as follows:

Per cent aluminum.	Total No. cast.	No. perfect.	No. perfect under 850 grains.	Wgt. of lightest perfect casting.	Aver. pot temp.	Aver. wgt. cast.	Aver. wgt. perfect castings.	Per cent acceptable castings.
0.04	16	12	6	710	478	847	847	37.5
0.05	16	11	5	745	491	857	899	31.2
0.26	16	8	5	675	493	801	858	31.2
0.44	16	13	9	670	480	783	810	56.2
1.2	11	9	2	725	510	938	942	18.2
1.92	18	15	0	880	500	1,085	1,058	0.0
2.0	3	2	0	1,300	492	1,300	1,300	0.0
5.3	19	17	17	415	457	467	468	89.5

Alloys made up from impure spelter in this proportion gave acceptable results, but not the remarkable castings obtained in the last run of the above table. These are very liable to failure with time, as the corrosion tests upon the 20 per cent aluminum, 80 per cent zinc alloy indicate. Definite conclusions as to the endurance of castings made with the pure spelter alloy cannot be stated until a greater time has elapsed. The use of any aluminum in a zinc bath brings out most strongly the necessity of a pyrometer for obtaining accurate temperature regulation. The clearing action which lessens the production of scum does away with the oxidation colors characteristic of a zinc bath, and makes temperature judging by the eye extremely difficult. In appearance the aluminum-zinc castings are smoother than those of spelter alone, an effect which is produced by the high temperatures of casting the low aluminum alloys and the extreme fluidity of the 5 per cent mixture. The finished castings are harder than those of high grade spelter.

Conclusions from Experiments

Cadmium, when present in spelter, produces in it a hot short condition which unfits it for use in castings where power of resistance to cooling stresses is required. Lead, when present as an impurity, produces an increasingly bad effect upon the alloy. The percentage of failure is greater than with pure spelter, and it produces a tendency toward heavy castings, and hence uneconomical use of metal. The effect of iron in amounts greater than are allowable in spelter, is to increase the tendency to failure. The results are erratic and the trouble is probably due to the segregation of crystals of iron-zinc alloy. Arsenic in the amounts in which it occurs naturally in spelter has little or no effect. In larger proportions it acts like iron. Aluminum, when present in amounts between traces and 5 per cent, produces alloys impossible to use for this purpose. With from 5.0 to 5.5 per cent aluminum the alloy with pure zinc possesses great possibilities, because of its lightness, smoothness and general adaptability to this purpose. High grade spelter only must be used, otherwise failure of the casting with time will occur. In general the effect of the common impurities in spelter upon slush castings can be explained by the known physical characteristics of the corresponding alloys.

Aluminum Production Grows

Aluminum production is constantly increasing, the output in the United States last year having aggregated 79,129,000 pounds, against 72,379,000 pounds in 1913. In 1904 the aluminum

production was only 8,600,000 and the gain in a decade was 70,529,000 pounds. In 1883, when the first statistics on aluminum production were recorded, the output totaled only 83 pounds. Aluminum exports in 1914 had a value of $1,546,510, as compared with $966,094 the previous year. Bauxite, the raw material from which aluminum is made, is mined largely in Arkansas, Tennessee, Georgia and Alabama. The production of bauxite in the United States in 1914 was 219,318 long tons, valued at $1,069,194, an increase of 9,077 tons, or 4.3 per cent in quantity and $71,495 or 7.1 per cent in value, as compared with the output in the preceding year.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

How to Brighten Brass Castings

How can we brighten finished brass castings that have turned dark?

If the castings are small and have been polished, tumbling with leather meal in a wooden cylinder will restore the luster. If the castings have been polished and are large, buffing on a cotton buff wheel, using Vienna lime as a buffing compound, is the only practical method. No mechanical process will restore the original luster to darkened polished brass without injury to the smooth surface.

If the original finish was a bright matte surface or one produced by chemical action, the luster may be restored by using the following solution as a dip:

Sulphuric acid ... 1 gallon
Nitric acid ..... 3 quarts
Common salt ... 2 tablespoonfuls

Avoid introducing water into the solution, as it will cause a roughened brass surface. Immerse the castings quickly and rinse in clear, cold water, then in clear, hot water, and dry with clean, dry hardwood sawdust.

Porous Brass Bushings

We are making 60-pound brass bushings, but we are troubled with porosity. Our mixture consists of clean sheet copper, 80 pounds; tin, 10 pounds, and lead, 10 pounds. The molds are provided with two sprues. The gates enter at the bottom, and the metal has been poured both hot and cold without satisfactory results.

It is evident from your experiments of pouring the molds both hot and cold that the temperature of the metal has nothing to do with the porous condition of the casting and this point can be eliminated from consideration. Undoubtedly your methods of melting are at fault and if the heavy section of the metal is broken cold in all probability it will be found to be anything but homogenous and instead of having a dense, uniform whitish fracture, there will be a mixture of several colors. This is due to oxidation and the remedy is even more careful melting than has prevailed heretofore. The addition of a small amount of rock salt and the use of sufficient charcoal to cover the surface of the molten metal at all times will help in preventing porosity, and after exercising care in this way, add one pound of 15 per cent phosphor-copper to every 100 pounds of metal melted. The alloy is one in general use and of itself will give no trouble. The metals used for making this mixture are good.

Solid Copper Castings

We would like to have some information regarding the making of copper castings which must be solid and free from blow-holes. The castings should be made of 98 per cent copper and should have an electrical conductivity of 85 per cent. I have used a small percentage of phosphor-copper to insure solidity, but unfortunately this reduced the electrical conductivity. The castings are to be used for electrical purposes and will not admit of the use of phosphorus.

Copper castings possessing high electrical conductivity cannot be made by the use of phosphorus or zinc, or any of the deoxidizing agents usually employed in the manufacture of brass and bronze castings. Silicon also has a detrimental effect on the conductivity of copper and for that reason its use is out of the question for electrical castings, unless the copper can be poled and thus brought to the condition known as *tough pitch*, at which stage it is necessary only to add about 0.02 per cent silicon. Poling is not practical in the case of crucible melted copper and when silicon is used to make casting of high electrical conductivity by the crucible process, the silicon has to be combined with some element which will not materially effect the conductivity itself, but which has the power to throw the silicon out of solution in the copper, permitting sufficient to be used to insure solidity and leaving only mere traces to effect the conductivity.

Metallic Packing for Locomotives

We would like to have a mixture for metallic packing for locomotives, which will be subjected to the action of superheated steam. This must have good anti-frictional properties and must resist high temperatures. We have been informed that a mixture of 60 per cent copper and 40 per cent lead is a good alloy and if so, we would like to know how it should be melted and the metal cast to obtain the best results. Our metal is melted in an oil-fired tilting furnace.

No particular difficulty should be experienced in making an alloy consisting of 60 per cent copper and 40 per cent lead. The copper is melted first and the lead is added while stirring the bath. The difficulty consists in retaining the lead in solid solution with the copper and to accomplish this considerable experimenting will be necessary. Sulphur generally is used to hold the lead in combination and this may be added in the form of roll sulphur or by means of plaster of paris. The aim should be to get a fluid slag and to obtain this soda ash, borax and sodium chloride are used in conjunction with the plaster. When melting the copper to form the alloy, use a cover of powdered glass.

Propeller and Connecting Rod Mixtures

We would like to have a mixture for propellers for motor boats which will provide a metal that can be bent without breaking. Also, we would like to know what alloy is best adapted for connecting rods that connect the piston to the crankshaft. We would like a mixture that will give a tough metal.

The following mixture will be found satisfactory:

Copper, 81 per cent; tin, 7 per cent; lead, 2.5 per cent, and zinc, 3.5 per cent.

For connecting rods use the following alloy:

Copper, 88 per cent; tin, 10 per cent, and zinc, 2 per cent.

PR The Time Given on this Sheet is for all Tools in this Class When Used in Tool Posts as Shown in Sketches. $\frac{1}{2} \times \frac{3}{4}$ TO $1 \times 1\frac{1}{2}$

SIZE OF TOOL	WIDTH	1/2	5/8	3/4	7/8	1	TAYLOR ELEMENTARY SYSTEM UNIT TIME
	DEPTH	3/4	1	1 1/8	1 3/8	1 1/2	
TIME FOR PUTTING IN *In Minutes*		0.40	0.44	0.58			**PUT TOOL IN TOOL POST HAVING ONE SET SCREW**
Select Tool from Tray		0.03	0.03	0.04			
Measure Height of Cutting Edge		0.07	0.07	0.07			
Select Packing to Bring Cutting Edge to Height of Center		0.03	0.03	0.09			
Put Tool and Packing in Tool Post		0.03	0.04	0.04			
Tighten Screw Down Lightly on Tool with Wrench		0.03	0.04	0.04			
Knock Tool Around in Position		0.06	0.07	0.13			
Tighten Screw Down Hard with Wrench		0.06	0.06	0.12			
Remove Wrench and Place on Tray		0.03	0.04	0.05			
TIME FOR REMOVING *In Minutes*		0.17	0.18	0.18			**REMOVE TOOL FROM TOOL POST HAVING ONE SET SCREW**
Pick Up Wrench		0.03	0.03	0.03			
Put Wrench on Set Screw		0.02	0.02	0.02			
Loosen Set Screw		0.06	0.06	0.06			
Remove Tool and Packing		0.02	0.03	0.03			
Replace Tool and Packing on Tray		0.02	0.02	0.02			
Leave Wrench on Tool Post							
TIME FOR PUTTING IN *In Minutes*				0.76		0.78	**PUT TOOL IN TOOL POST HAVING TWO SET SCREWS**
Select Tool from Tray				0.04		0.04	
Measure Height of Cutting Edge				0.07		0.07	
Select Packing to Bring Cutting Edge to Height of Center				0.09		0.09	
Put Tool and Packing in Tool Post				0.11		0.13	
Tighten Two Set Screws Down Lightly on Tool with Wrench				0.17		0.17	
Knock Tool Around in Position				0.12		0.12	
Tighten Two Set Screws Down Hard with Wrench				0.13		0.13	
Remove Wrench and Place on Tray				0.03		0.03	
TIME FOR REMOVING *In Minutes*				0.39		0.39	**REMOVE TOOL FROM TOOL POST HAVING TWO SET SCREWS**
Pick Up Wrench				0.05		0.05	
Put Wrench on Set Screw				0.02		0.02	
Loosen First Set Screw				0.06		0.06	
Move Wrench to Second Set Screw				0.02		0.02	
Loosen Second Set Screw				0.08		0.08	
Remove Tool and Packing				0.06		0.06	
Replace Tool and Packing on Tray				0.08		0.08	

See Sketch No. 1 at Top of Sheet.

See Sketch No. 1 at Top of Sheet.

See Sketch No. 2 at Top of Sheet.

See Sketch No. 2 at Top of Sheet.

OBSERVATION SHEET

OBSERVER'S NAME MACHINE No. DATE 19

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 10 32 4 J. R. Flask 10 x 16 Cope 4" Drag 3"

DETAIL OPERATIONS	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Con-tinuous Time	Indi-vidual Time	Mini-mum Time
Clean platen & put match & frame in place Clean frame	4	04	4	04	3	03	3	03	3	03	3	03	3	03	3	03	4	04	3	03	.03
1 Separate cope & drag	7	03	6	02	5	02	5	02	6	03	5	02	5	02	5	02	7	03	5	02	.02
2 Clamp drag (1 cl'mp)	10	03	9	03	8	03	9	04	9	03	10	05	8	03	8	03	10	03	9	04	.03
Put drag in place on hard sand match	13	03	13	04	11	03	12	03	14	05	15	05	11	03	14	06	13	03	13	04	.04
Sprinkle with parting	18	05	18	05	17	06	20	08	20	06	23	08	17	06	21	07	19	06	20	07	.06
3 Put riddle on drag	21	03	21	03	20	03	23	03	22	02	26	03	20	03	24	03	22	03	23	03	.03
4 Put sd. in R (1 shv.)	26	05	25	04	25	05	28	05	27	05	31	05	28	08	29	05	27	05	28	05	.05
5 Riddle	31	05	31	06	28	03	33	05	33	06	38	07	34	06	36	07	33	06	35	07	.06
6 Hang R on nail	33	02	33	02	30	02	35	02	35	02	40	02	36	02	38	02	35	02	37	02	.02
Fill drag with sand	40	07	40	07	36	06	40	05	40	05	47	07	41	05	43	05	41	06	42	05	.06
Jar (10 jolts)	46	06	46	06	41	05	46	06	49	09	52	05	47	06	49	06	48	07	49	07	.06
Strike off & put bottom bd. in place	56	10	52	06	49	08	52	06	54	05	59	07	54	07	57	08	55	07	57	08	.07
7 Swing yoke forward	59	03	54	02	51	02	54	02	56	02	62	03	57	03	59	02	57	02	60	03	.02
8 Squeeze drag	63	04	58	04	55	04	59	05	60	04	66	04	61	04	64	05	62	05	65	05	.04
9 Swing yoke back	65	02	60	02	57	02	61	02	62	02	68	02	63	02	66	02	64	02	67	02	.02
Roll over	70	05	65	05	62	05	66	05	66	04	73	05	68	05	71	05	69	05	72	05	.05
Put hard sand match on table	73	03	68	03	65	03	69	03	69	03	76	03	71	03	74	03	72	03	75	03	.03
2 Clamp cope half of flask (1 clamp)	76	03	72	04	70	05	73	04	73	04	80	04	74	03	78	04	77	05	78	03	.03
Put cope in place	80	04	75	03	74	04	77	04	77	04	89	09	77	03	83	05	81	04	82	04	.04
Sprinkle with parting	88	08	81	06	81	07	83	06	82	05	91	02	83	06	90	07	87	06	89	07	.06
3 Put riddle on cope	91	03	84	03	84	03	86	03	85	03	94	03	86	03	93	03	90	03	92	03	.03
4 Put sd. in R (1 sh'vl)'	95	04	90	06	89	05	91	05	90	05	98	04	90	04	98	05	95	05	96	04	.05
5 Riddle	99	04	94	04	94	05	96	05	95	05	3	05	95	05	2	04	0	05	1	05	.05
6 Hang R on hook	1	02	96	02	96	02	98	02	97	02	5	02	97	02	4	02	2	02	3	02	.02
Fill cope with sand	9	08	1	05	2	06	5	07	7	10	11	06	4	07	10	06	8	06	9	06	.07
Tuck with hands	16	07	9	08	8	06	11	06	15	08	19	08	10	06	17	07	15	07	15	06	.07
11 Strike off—put cope bd. in place	22	06	15	06	15	07	16	05	21	06	25	06	17	07	23	06	22	07	20	05	.07
7 Swing yoke forward	24	02	17	02	17	02	18	02	24	03	27	02	20	03	25	02	24	02	23	03	.02
8 Squeeze cope	28	04	21	04	22	05	23	05	27	03	30	03	26	06	30	05	29	05	27	04	.04
9 Swing yoke back	30	02	23	02	24	02	25	02	29	02	32	02	28	02	32	02	31	02	29	02	.02
Put cop bd. on table	34	04	26	03	27	03	28	03	33	04	36	04	30	02	34	02	33	02	32	03	.03
10 Cut sprue	38	04	30	04	31	04	32	04	38	05	42	06	36	06	40	06	39	06	37	05	.05
Draw cope	41	03	33	03	34	03	35	03	40	02	46	04	39	06	43	03	41	02	41	04	.03
Lay cope on bench	45	04	36	03	39	05	40	05	45	05	50	04	43	04	47	04	45	04	45	04	.04
12 Blow off excess sand	47	02	39	03	42	03	44	04	48	03	56	06	46	03	50	03	49	04			.04
Draw frame	59	12	49	10	53	11	53	09	59	11	70	14	57	11	62	12	63	14	53	08	.11
Lay frame on hard sd. match	65	06	54	05	58	05	61	08	64	05	76	06	62	05	68	06	70	07	58	05	.06
Pick up C bring to D	69	04	60	06	62	04	66	05	68	04	80	04	67	05	71	03	77	07	62	04	.05
Close mold	73	04	64	04	66	04	69	03	72	04	85	05	71	04	74	03	80	03	66	04	.04
Open-flask	76	03	67	03	69	03	75	06	76	04	89	04	74	03	78	04	83	03	70	04	.04
Set flask (D up) on bench	80	04	70	03	74	05	79	04	79	03	92	03	78	04	82	04	86	03	73	03	.04
R'd off edges of m'ld	82	02	73	03	77	03	82	03	82	03	94	02	81	03	86	04	90	04	77	04	.03
Carry out (see T. S.																					.08
Return (No. 1																					.06
																					1.96

FIG. 1—ANOTHER DATA SHEET OF A MACHINE SHOP TIME STUDY
FIG. 2—OBSERVATION SHEET SHOWING HOW TIME STUDIES ARE MADE

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

TABLE CONVERTING MILLIMETERS TO INCHES.

By Thomas A. Rance

Based on 1 millimeter = 0.03937 inch.

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
1	.03937	51	2.00787	101	3.97637	151	5.94487	201	7.91337
2	.07874	52	2.04724	102	4.01574	152	5.98424	202	7.95274
3	.11811	53	2.08661	103	4.05511	153	6.02361	203	7.99211
4	.15748	54	2.12598	104	4.09448	154	6.06298	204	8.03148
5	.19685	55	2.16535	105	4.13385	155	6.10235	205	8.07085
6	.23622	56	2.20472	106	4.17322	156	6.14172	206	8.11022
7	.27559	57	2.24409	107	4.21259	157	6.18109	207	8.14959
8	.31496	58	2.28346	108	4.25196	158	6.22046	208	8.18896
9	.35433	59	2.32283	109	4.29133	159	6.25983	209	8.22833
10	.39370	60	2.36220	110	4.33070	160	6.29920	210	8.26770
11	.43307	61	2.40157	111	4.37007	161	6.33857	211	8.30707
12	.47244	62	2.44094	112	4.40944	162	6.37794	212	8.34644
13	.51181	63	2.48031	113	4.44881	163	6.41731	213	8.38581
14	.55118	64	2.51968	114	4.48818	164	6.45668	214	8.42518
15	.59055	65	2.55905	115	4.52755	165	6.49605	215	8.46455
16	.62992	66	2.59842	116	4.56692	166	6.53542	216	8.50392
17	.66929	67	2.63779	117	4.60629	167	6.57479	217	8.54329
18	.70866	68	2.67716	118	4.64566	168	6.61416	218	8.58266
19	.74803	69	2.71653	119	4.68503	169	6.65353	219	8.62203
20	.78740	70	2.75590	120	4.72440	170	6.69290	220	8.66140
21	.82677	71	2.79527	121	4.76377	171	6.73227	221	8.70077
22	.86614	72	2.83464	122	4.80314	172	6.77164	222	8.74014
23	.90551	73	2.87401	123	4.84251	173	6.81101	223	8.77951
24	.94488	74	2.91338	124	4.88188	174	6.85038	224	8.81888
25	.98425	75	2.95275	125	4.92125	175	6.88975	225	8.85825
26	1.02362	76	2.99212	126	4.96062	176	6.92912	226	8.89762
27	1.06299	77	3.03149	127	4.99999	177	6.96849	227	8.93699
28	1.10236	78	3.07086	128	5.03936	178	7.00786	228	8.97636
29	1.14173	79	3.11023	129	5.07873	179	7.04723	229	9.01573
30	1.18110	80	3.14960	130	5.11810	180	7.08660	230	9.05510
31	1.22047	81	3.18897	131	5.15747	181	7.12597	231	9.09447
32	1.25984	82	3.22834	132	5.19684	182	7.16534	232	9.13384
33	1.29921	83	3.26771	133	5.23621	183	7.20471	233	9.17321
34	1.33858	84	3.30708	134	5.27558	184	7.24408	234	9.21258
35	1.37795	85	3.34645	135	5.31495	185	7.28345	235	9.25195
36	1.41732	86	3.38582	136	5.35432	186	7.32282	236	9.29132
37	1.45669	87	3.42519	137	5.39369	187	7.36219	237	9.33069
38	1.49606	88	3.46456	138	5.43306	188	7.40156	238	9.37006
39	1.53543	89	3.50393	139	5.47243	189	7.44093	239	9.40943
40	1.57480	90	3.54330	140	5.51180	190	7.48030	240	9.44880
41	1.61417	91	3.58267	141	5.55117	191	7.51967	241	9.48817
42	1.65354	92	3.62204	142	5.59054	192	7.55904	242	9.52754
43	1.69291	93	3.66141	143	5.62991	193	7.59841	243	9.56691
44	1.73228	94	3.70078	144	5.66928	194	7.63778	244	9.60628
45	1.77165	95	3.74015	145	5.70865	195	7.67715	245	9.64565
46	1.81102	96	3.77952	146	5.74802	196	7.71652	246	9.68502
47	1.85039	97	3.81889	147	5.78739	197	7.75589	247	9.72439
48	1.88976	98	3.85826	148	5.82676	198	7.79526	248	9.76376
49	1.92913	99	3.89763	149	5.86613	199	7.83463	249	9.80313
50	1.96850	100	3.93700	150	5.90550	200	7.87400	250	9.84250

(*Continued on Data Sheet No.* 200.)

TABLE CONVERTING MILLIMETERS TO INCHES.

By Thomas A. Rance

(*Continued from Data Sheet No.* 199.)

Based on 1 millimeter = 0.03937 inch.

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
251	9.88187	301	11.85037	351	13.81887	401	15.78737	451	17.75587
252	9.92124	302	11.88974	352	13.85824	402	15.82674	452	17.79524
253	9.96061	303	11.92911	353	13.89761	403	15.86611	453	17.83461
254	9.99998	304	11.96848	354	13.93698	404	15.90548	454	17.87398
255	10.03935	305	12.00785	355	13.97635	405	15.94485	455	17.91335
256	10.07872	306	12.04722	356	14.01572	406	15.98422	456	17.95272
257	10.11809	307	12.08659	357	14.05509	407	16.02359	457	17.99209
258	10.15746	308	12.12596	358	14.09446	408	16.06296	458	18.03146
259	10.19683	309	12.16533	359	14.13383	409	16.10233	459	18.07383
260	10.23620	310	12.20470	360	14.17320	410	16.14170	460	18.11020
261	10.27557	311	12.24407	361	14.21257	411	16.18107	461	18.14957
262	10.31494	312	12.28344	362	14.25194	412	16.22044	462	18.18894
263	10.35431	313	12.32281	363	14.29131	413	16.25981	463	18.22831
264	10.39368	314	12.36218	364	14.33068	414	16.29918	464	18.26768
265	10.43305	315	12.40155	365	14.37005	415	16.33855	465	18.30705
266	10.47242	316	12.44092	366	14.40942	416	16.37792	466	18.34642
267	10.51179	317	12.48029	367	14.44879	417	16.41729	467	18.38579
268	10.55116	318	12.51966	368	14.48816	418	16.45666	468	18.42516
269	10.59053	319	12.55903	369	14.52753	419	16.49603	469	18.46453
270	10.62990	320	12.59840	370	14.56690	420	16.53540	470	18.50390
271	10.66927	321	12.63777	371	14.60627	421	16.57477	471	18.54327
272	10.70864	322	12.67714	372	14.64564	422	16.61414	472	18.58264
273	10.74801	323	12.71651	373	14.68501	423	16.65351	473	18.62201
274	10.78738	324	12.75588	374	14.72438	424	16.69288	474	18.66138
275	10.82675	325	12.79525	375	14.76375	425	16.73225	475	18.70075
276	10.86612	326	12.83462	376	14.80312	426	16.77162	476	18.74012
277	10.90549	327	12.87399	377	14.84249	427	16.81099	477	18.77949
278	10.94486	328	12.91336	378	14.88186	428	16.85036	478	18.81886
279	10.98423	329	12.95273	379	14.92123	429	16.88973	479	18.85823
280	11.02360	330	12.99210	380	14.96060	430	16.92910	480	18.89760
281	11.06297	331	13.03147	381	14.99997	431	16.96847	481	18.93697
282	11.10234	332	13.07084	382	15.03934	432	17.00784	482	18.97634
283	11.14171	333	13.11021	383	15.07871	433	17.04721	483	19.01571
284	11.18108	334	13.14958	384	15.11808	434	17.08658	484	19.05508
285	11.22045	335	13.18895	385	15.15745	435	17.12595	485	19.09445
286	11.25982	336	13.22832	386	15.19682	436	17.16532	486	19.13382
287	11.29919	337	13.26769	387	15.23619	437	17.20469	487	19.17319
288	11.33856	338	13.30706	388	15.27556	438	17.24406	488	19.21256
289	11.37793	339	13.34643	389	15.31493	439	17.28343	489	19.25193
290	11.41730	340	13.38580	390	15.35430	440	17.32280	490	19.29130
291	11.45667	341	13.42517	391	15.39367	441	17.36217	491	19.33067
292	11.49604	342	13.46454	392	15.43304	442	17.40154	492	19.37004
293	11.53541	343	13.50391	393	15.47241	443	17.44091	493	19.40941
294	11.57478	344	13.54328	394	15.51178	444	17.48028	494	19.44878
295	11.61415	345	13.58265	395	15.55115	445	17.51965	495	19.48815
296	11.65352	346	13.62202	396	15.59052	446	17.55902	496	19.52752
297	11.69289	347	13.66139	397	15.62989	447	17.59839	497	19.56689
298	11.73226	348	13.70076	398	15.66926	448	17.63776	498	19.60626
299	11.77163	349	13.74013	399	15.70863	449	17.67713	499	19.64563
300	11.81100	350	13.77950	400	15.74800	450	17.71650	500	19.68500

(*Continued on Data Sheet No.* 201.)

The Application of Scientific Management---II

Importance of Proper Time Studies and Their Purposes — How Such Studies Should Be Made—Value of Scientific Management to the Foundry

By H K Hathaway

THAT phase of the Taylor system which is apt to attract the attention of managers most forcibly is time study and its use in the setting of piece rates, or establishing the time work should take. Many are the crimes committed in the name of *time study,* and little is it understood. Not long ago I heard a lecture describing what purported to be a system of management, and after having set forth in considerable detail the worst kind of a hit-or-miss, man-driving scheme in which the management made no effort in any way to aid either foreman or workman, and after advocating methods which scientific management would abhor, the lecturer complacently said: "This may sound like the Taylor system, but we have left out all of the undesirable features; we have no shoe-clerks with stop-watches". To anyone familiar with scientific management such statements are so ridiculous as to be laughable, but I regret to say that I do know of cases where young men who have been clerks or just out of college possessing no practical experience have been given stop-watches and sent into shops by managers who, having heard of the results achieved under scientific management, considered time study as the one essential feature, and decided to try it for a few weeks to see if it would accomplish the same results in their plants. Needless to say that in such cases the results are worthless if not disastrous.

A paper read at the twentieth meeting of the American Foundrymen's Association, Atlantic City, N. J., Sept. 28-Oct. 1. The author, H. K. Hathaway, is affiliated with the Tabor Mfg. Co., Philadelphia. This is the second of two installments.

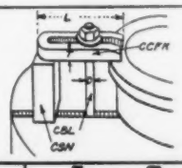
The Self-Styled Efficiency Expert

There is also the self-styled efficiency expert who with a stop-watch in each hand and his hands in his pockets attempts to make time studies while trying to appear to the man whose work he is timing to be interested only in a fly crawling along the crane runway.

This is *not* time study. Such methods are not only an insult to the workmen concerned, but are absolutely of no value in practical work. For a detailed description of the theory of elementary time study I would refer you to an article written some years ago, entitled "Elementary Time Study as a Part of the Taylor System of Scientific Management", which was published in *Industrial Engineering* in 1911, and which has been reprinted in a book, already mentioned, comprising a large number of articles on scientific management by various writers, brought together and edited by C. B. Thompson, and published by the Harvard University Press, Cambridge, Mass.

Time studies should almost never be undertaken except for the purpose of improving methods, and in no case for the purpose of setting tasks until a suitable foundation has been laid. Virtually all of the other features of the system must be in operation before any attempt is made to make or use time studies. This I cannot too strongly emphasize, and from what I have already said its importance should be obvious.

The purposes of time study are as follows: To find the best method both as to quality and time; to locate defects in equipment, or conditions



MEDIUM SIZE
CCFK

Diam. of Bolt D	Length of Clamp L	Thickness of Clamp	Weight of Clamp Lbs. Oz.
5/8"	10	1 1/4"	3 11
3/4"	11	1 3/8"	6 -
7/8"	12	1 1/2"	7 8
1"	13	1 3/4"	10 8

CCFK

Sizes Given in the Table

Use One **CBL** *and One* **CSN**

TAYLOR ELEMENTARY SYSTEM UNIT TIME

DIAMETER OF BOLT	5/8 AND 3/4				7/8 AND 1					
LENGTH OF BOLT	**6**	**12**	**14**	**18**	**6**	**12**	**18**	**24**	**30**	**36**
TIME FOR CLAMPING *In Minutes*	0.42	0.45	0.45	0.51	0.48	0.53	0.57	0.69	0.78	0.92
Lift Bolt, Clamp and Block to Table, Bolt Remaining in Hand	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.13	0.14	0.17
Put Bolt in Slot	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.06	0.07
Slip Clamp on Bolt and on Work	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
Put Block under Clamp	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10
Screw Nut Down with Fingers	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14
Tighten Nut Lightly with Wrench	0.08	0.08	0.08	0.10	0.11	0.12	0.13	0.15	0.17	0.19
Draw Nut Down Tight with Wrench	0.09	0.09	0.09	0.10	0.09	0.10	0.11	0.13	0.15	0.17
TIME FOR REMOVING *In Minutes*	0.16	0.17	0.17	0.18	0.22	0.22	0.24	0.26	0.29	0.33
Loosen Nut with Wrench	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.25
Remove Clamp from Bolt	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
TIME FOR CLAMPING *In Minutes*	0.30	0.33	0.34	0.37	0.35	0.39	0.42	0.51	0.58	0.68
Slip Clamp on Bolt and on Work	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.08
Put Block under Clamp	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.07	0.08	0.10
Screw Nut Down with Fingers	0.05	0.06	0.06	0.07	0.06	0.07	0.08	0.10	0.11	0.14
Tighten Nut Lightly with Wrench	0.08	0.08	0.08	0.10	0.11	0.12	0.13	0.15	0.17	0.19
Draw Nut Down Tight with Wrench	0.08	0.09	0.10	0.10	0.09	0.10	0.11	0.13	0.15	0.17
TIME FOR REMOVING *In Minutes*	0.24	0.25	0.25	0.27	0.30	0.30	0.33	0.37	0.41	0.47
Loosen Nut with Wrench	0.11	0.12	0.12	0.13	0.17	0.17	0.19	0.20	0.22	0.25
Remove Clamp from Bolt	0.05	0.05	0.05	0.15	0.05	0.05	0.05	0.05	0.06	0.07
Remove Bolt from Slot	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.05	0.05
Put Clamp, Bolt and Block in Tote Box on Floor	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08	0.08	0.10

CLAMPING
BOLT TO BE PUT IN SLOT
The Time Given in this Section to Be Used ONLY FOR FIRST PIECE *in Lot or on other Pieces* WHEN BOLT HAS TO BE PUT INTO SLOT.

REMOVING
BOLT NOT TO BE TAKEN FROM SLOT
The Time Given in this Section to Be Used for All Pieces in Lot EXCEPTING THE LAST PIECE.

CLAMPING
BOLT ALREADY IN SLOT
The Time Given in this Section to Be Used for All Pieces in the Lot AFTER *the* FIRST PIECE *When Bolt has Not Been Removed.*

REMOVING
BOLT TO BE TAKEN FROM SLOT
The Time Given in this Section to Be Used ONLY FOR LAST PIECE *in Lot or on other Pieces* WHEN BOLT HAS TO BE TAKEN FROM SLOT.

FIG. 3—DATA SHEET OF MACHINE SHOP TIME STUDY COVERING THE PUTTING ON AND TIGHTENING OF A BOLT AND CLAMP OF GIVEN SIZE

OBSERVATION SHEET

OBSERVER'S NAME **MACHINE No.** **DATE** **19**

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 8 30 R. Flask 19½ x 10½ Cope 3½" · Drag 3"

DETAIL OPERATIONS	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Minimum Time
Separate c & d	1	01	1	01	1	01	1	01	1	01	1	01	1	01									01
Clamp d (1 clamp)	6	05	4	03	4	03	4	03	4	03	6	05	4	03									.03
Put d on platen	10	04	7	03	7	03	7	03	6	02	12	06	7	03									.03
Put plate on drag	13	03	10	03	12	05	10	03	9	03	16	04	11	04									.03
Sprinkle plate with parting	18	05	17	07	17	05	15	05	16	07	23	07	16	05									.05
Put R. on plate	20	02	19	02	19	02	17	02	18	02	25	02	18	03									.02
Put handful core sd. in R	24	04	23	04	23	04	20	03	22	04	29	04	21	03									.04
Riddle	26	02	27	04	27	04	24	04	25	03	33	04	25	04									.04
Put shovel sd. in R	32	06	32	05	33	06	31	07	30	05	37	04	30	05									.05
R	38	06	43	11	40	07	39	08	37	07	43	06	36	06									.07
Hang R. on hook (on wall over yoke)	39	01	44	01	41	01	40	01	38	01	44	01	37	01									.01
Tuck with hands	47	08	52	08	49	08	47	07	47	09	53	09	45	08									.08
Strike off	67	20	71	19	70	21	63	16	60	13	64	11	61	16	Must be done very cleanly.								.01
Blow off & clean pl'te thoroughly	84	17	86	15	88	18	76	13	77	17	95	31	76	15									.15
Put false pl'te in pl'ce	91	07	94	08	96	08	83	07	83	06	1.03	08	6	06									.07
Clamp C. (1 clamp)	97	06			0	04	88	05	89	06	7	04	11	05	Includes moving to bench.								.05
Put C. on D	5	07	0	06	5	05	92	04	94	05	11	04	17	06									.05
Roll over (Empty fla. except for cheek)	8	03	5	05	9	04	0	08	99	05	15	04	21	04									.04
Sprinkle with parting	12	04	9	04	13	04	4	04	4	05	19	04	25	04									.04
Put R. on flask	14	02	11	02	15	02	6	02	6	02	21	02	27	02									.02
							15	09	16	10													
Put 1 shovel sd. in R.	20	06	18	07	24	09	20	05	21	05	26	05	33	06									.05
R	26	06	23	05	30	06	27	07	26	05	30	04	38	05									.05
Hang R. on hook	27	01	24	01	31	01	28	01	27	01	31	01	39	01									.01
Tuck with hands	35	08	28	04	37	06	35	07	34	07	38	07	45	06									.06
Fill D. with sd. (1 shovel	43	08	36	08	42	05	42	07	41	07	44	06	51	06									.07 .07
Pein with peiner	55	12	54	18	59	17	59	17	57	16	62	18	68	17									.16
Strike off & put b. bd. in place	69	14	66	12	73	14	70	11	72	15	79	17	82	14	Includes picking up B. B. from pile 5 feet away.								.14
Rap bd. in place with peiner	72	03	72	06	78	05	77	07	76	04	84	05	88	06									.06
Roll over	83	11	85	13	86	08	89	12	84	08	91	07	96	08									.08
Sprinkle	88	05	90	05	91	05	92	03	88	04	97	06	2	06									.05
Put R. on C	90	02	92	02	93	02	95	03	90	02	99	02	4	02									.02
Put 1 shov. sd. in R	5	05	5	05	5	05	7	07	5	05	6	6	6	06	5	05	6	06	5	05			.05
Riddle	10	05	10	05	9	04	11	04	9	04	10	04	11	05	9	04	12	06	9	04			.05
Hang R. on hook	12	02	11	01	10	01	12	01	10	01	11	01	12	01	10	01	13	01	10	01			.01
Tuck with hands	20	08	19	08	19	09	21	09	18	08	19	08	21	09	19	09	22	08	15	05			.08
Fill with sd. (1 shov.)	29	09	28	09	26	07	30	09	25	07	26	07	27	06	26	07	31	09	21	06			.07
Pein with peiner	47	18	46	18	42	16	45	15	42	17	42	16	42	15	43	17	50	19	37	16			.16
Strike off—put C. bd. in place (carried on bench)	58	11	58	12	55	13	56	11	51	09	52	10	52	10	54	11	61	11	8	08			.11
Swing yoke forward	60	02	60	02	2	02	58	02	53	02	54	02	54	02	56	02	63	02	10	02			.02
Push flask back	62	02	62	02	4	02	66	08	55	02	58	04	57	03	58	02	65	02	13	03			.05
Squeeze	67	05	67	05	9	05			61	06	63	05	62	05	64	06	70	05	18	05			.02
Swing yoke back	69	02	69	02	10	01	67	01	62	01	64	01	63	01	65	01	71	01	19	01			.01
Remove C. bd.	73	04	73	04	14	04	70	03	66	04	69	05	69	06	69	04	76	05	23	04			.04
Cut sprue (cutter on yoke)	78	05	78	05	19	05	76	06	70	04	75	06	73	04	75	06	82	06	28	05			.05
Blow off	85	07	86	08	26	07	88	12	78	08	84	09	80	07	85	10	90	08	38	10			.08
									26														
Rap	93	08	95	09	33	07	90	02	33	07	92	08	86	06	93	08	94	04	44	06			.06
Draw C	2	09	5	10	42	09	3	13	42	09	2	10	95	09	4	11	6	12	54	10			.10
Put C. on bench	5	03	8	03	46	04	7	04	46	04	5	03	0	05	8	04	9	03	58	04			.04
Blow off plate	9	04	13	05	54	08	12	05	54	08	9	04	5	05	15	07	13	04	64	06			.05
Draw false plate—put on fl	13	04	17	04	59	05	15	03	59	05	13	03	11	06	19	04	17	04	68	04			.04
Sprinkle cheek with graphite	23	10	30	13	1.25		26	11	70	11	23	10	29	18	30	11	29	12	79	11			.11
Blow off	29	06	35	05	32	07	35	09	75	05	28	05	34	05	38	08	34	05	85	06			.09
Bring D. to C	33	04	38	03	37	05	39	04	80	05	33	05	39	05	42	04	38	04	90	05			.04
Close	43	10	45	07	44	07	48	09	90	10	44	11	45	06	52	10	46	08	1	11			.08
Put C. bd. in place	47	04	50	05	49	05	51	03	95	05	48	04	49	04	58	06	49	03	5	04			.04
Roll over	58	11	57	07	56	07	58	07	1	06	55	07	56	07	65	07	56	07	13	08			.07
Draw drag	63	05	63	06	60	04	63	05	6	05	60	05	60	04	71	06	60	04	17	04			.04
Put on bench	67	04	66	03	64	04	67	04	10	04	64	04	64	04	74	03	64	04	21	04			.04
Draw plate	74	07	74	08	70	06	73	06	17	07	70	06	74	10	84	10	72	08	26	05			.06
Put plate on yoke	76	02	77	03	72	02	75	02	19	02	72	02	76	02	86	02	75	03	28	02			.02
Repair mold (pc)							87	12					85	09	1.09	23							.02
Bring D. to C	80	04	80	03	78	06	91	04	26	07	78	06	0	15	13	04	80	05	32	04			.04
Close mold	3	03	26 29	03	3	03	3	03	3	03	3	03	3	03	3	03	3	03	2	02			.03
Roll over	10	07	35	06	10	07	10	07	8	05	9	06	9	06	11	08	8	05	9	07			.07
Remove C. bd.—put on bench	13	03	39	03	13	03	13	03	11	03	12	03	12	03	13	02	11	03	13	03			.03
Unclamp flask	16	03	42	03	16	03	15	02	14	03	14	02	14	02	15	02	13	02	15	02			.02
Remove flask—put on bench	29	13	46	04	21	05	20	05	19	05	22	08	19	05	21	06	22	09	21	06			.06
Slick up mold	42	13	59	13	35	14	29	09	27	08	32	10	28	09	33	12	32	10	34	13			.12
Carry out	47	05	66	07	40	05	38	09	34	07	39	07	34	06	40	07	39	07	39	05			.07
Put on floor	50	03	68	02	42	02	41	03	38	04	42	03	37	03	43	03	42	03	42	03			.03
Return	54	04	73	05	47	05	46	05	43	05	47	05	42	05	48	05	47	05	46	04			.05
Clean up ar'nd mach.	time	per mold																					.02
Clean plate, 20 molds	50								Time per mold														.02
Clean pins 20 molds	10		20						Time per mold														.01
																							4.03
									20%	on handling time													.81
																							4.84

Time for 75 molds 6 hrs.. 3 min.

FIG. 4—OBSERVATION SHEET COVERING JOB ON SMALL MACHINE

which retard production; to establish standards as to methods, equipment, conditions, and time for doing work; and to enable the accurate fixing of time that any job should take without having to make new time studies of every new job, and to use the time thus established in the setting of piece rates that will be right and that will serve as a basis for the increased pay which the workman should receive as proper compensation for his co-operation.

Time study as practiced under the Taylor system does not, except in very highly specialized industries, consist of the study of any given job with reference to the time it should take to do that job alone. This might be the case in a concern manufacturing only one article where the same operators always did the same work. In a foundry, even one manufacturing a standard line of product, the study should be made of each of the small elementary operations entering into the performance of the work.

To illustrate this, reference to the instruction cards for making molds on a power squeezer shows that job split up into a great number of minute operations. Many of these operations have to be performed in connection with any job that may be done on this type of molding machine. They are briefly classified under the following headings:

Elementary operations concerned with handling machine.
Handling pattern and pattern carrier.
Handling flask.
Shoveling sand.
Handling finished mold.
Setting cores.

The illustrations given show time studies made in two different foundries on different jobs, and it is interesting to note that the same elements performed by different men at different times correspond very closely in the matter of time taken for their performance, and that if we eliminate those elements appearing in the job requiring the longer time we have practically the same time as is indicated for the job requiring the shorter time.

It will be apparent that any two jobs of the same general character will include a large number of the same elements, some being included in one job that do not appear in the other, and the sequence in which the elements occur may be different in each.

Consequently, what should be done is to make complete time studies of all of the different elements entering into the art of molding, properly tabulate and classify these data, and by putting the elements entering into any given job together in their proper order with the time for each, the time

OBSERVATION SHEET

OBSERVER'S NAME **MACHINE No.** **DATE** **19**

WORKMAN'S NAME AND QUALIFICATIONS

PIECE M 10 32 R. Flask 12 x 12. Cope 5". Drag 4".

DETAIL OPERATIONS	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Continuous Time	Individual Time	Minimum Time
1 Separate C. & D....	1	01	1	01	1	01	1	01	1	01	1	01	1	01	2	02	1	01	2	02	.01
2 Clamp C. (1 clamp).	3	02	3	02	3	02	5	04	3	02	4	03	3	02	4	02	4	03	5	03	.03
Clean platen & put cope in place.....	7	04	6	03	8	05	8	03	6	03	8	04	8	05	9	05	7	03	8	03	.03
Put m'tch pl. in pl'ce	11	04	10	04	12	04	12	04	9	03	12	04	11	03	12	03	10	03	11	03	.03
Clean plate with bl. valve.....					15	03													per	pc.	.03
Clamp drag (2 cl'ps)	15	04	13	03	20	05	19	07	13	04	15	03	15	04	17	05	14	04	15	04	.04
Put drag in place...	20	05	20	07	25	05	23	04	18	05	21	06	20	05	22	05	20	06	20	05	.05
Sprinkle part'g on D.	24	04	26	06	30	05	27	04	22	04	25	04	25	05	26	04	24	04	24	04	.04
3 Put riddle on drag..	27	03	28	02	33	03	30	03	24	02	27	02	27	02	28	02	27	03	27	03	.02
4 Put 1 shov. sd. on R.	33	06	33	05	38	05	36	06	29	05	32	05	32	05	32	04	31	04	32	05	.05
5 Riddle sd. in D... *	40	07	42	09	45	07	40	04	37	08	37	05	39	07	41	09	40	09	41	09	.07
6 Hang R. on hook...	42	02	44	02	47	02	42	02	39	02	39	02	41	02	43	02	42	02	43	02	.02
Fill drag with sand.†	50	08	52	08	57	10	49	07	47	08	47	08	47	06	52	09	50	08	51	08	.08
Tuck with shovel....	59	09	61	09	65	08	58	09	55	08	55	08	56	09	60	08	59	09	60	09	.09
Strike off & put bottom bd. in place.**	67	08	70	09	76	11	67	09	63	08	63	08	65	09	70	10	68	09	68	08	.09
Roll over.....	72	05	75	05	81	05	72	05	68	05	70	07	70	05	75	05	73	05	73	05	.05
Sprinkle part'g on pl.	77	05	80	05	86	05	78	06	75	07	76	06	75	05	79	04	77	04	78	05	.04
3 Put riddle on cope..	79	02	83	03	88	02	80	02	77	02	78	02	77	02	81	02	79	02	80	02	.02
4 Put 1 shov. sd. in R.	84	05	88	05	94	06	85	05	82	05	84	06	82	05	86	05	84	05	85	05	.05
5 Riddle sand n cope†	90	06	94	06	0	06	91	06	88	06	90	06	88	06	93	07	91	07	92	07	.06
Hang riddle on hook	92	02	96	02	2	02	93	02	90	02	92	02	90	02	95	02	93	02	94	02	.02
Fill cope with sand..†	97	05	0	04	7	05	99	06	95	05	97	05	95	05	0	05	98	05	98	04	.05
Tuck with hands....	03	06	6	06	13	06	5	06	2	07	3	06	1	06	6	06	4	06	5	07	.06
11 Strike off & put cope bd. in place.....††	12	09	14	08	21	08	13	08	10	08	12	09	8	07	14	08	11	07	12	07	.07
7 Swing yoke forward.	15	03	17	03	24	03	16	03	12	02	14	02	11	03	16	02	13	02	14	02	.02
8 Squeeze.....	19	04	21	04	28	04	21	05	16	04	19	05	15	04	20	04	17	04	18	04	.04
9 Swing yoke back....	21	02	23	02	30	02	23	02	18	02	21	02	17	02	22	02	19	02	20	02	.02
Put cope bd. on table	23	02	26	03	32	02	25	02	21	03	23	02	20	03	24	02	21	02	21	01	.02
10 Cut sprue.....	27	04	30	04	37	05	30	05	26	05	28	05	24	04	29	05	26	05	28	07	.05
12 Blow off excess sand	35	08	37	07	45	08	36	06	33	07	34	06	30	06	35	06	33	07	32	04	.06
Draw cope.....	37	02	40	03	48	03	39	03	37	04	38	04	33	03	38	03	38	05	37	05	.04
Lay cope on bench..	41	04	45	05	52	04	43	04	41	04	43	05	38	05	42	04	42	04	41	04	.04
Draw plate.....	50	09	57	12	63	11	52	09	49	08	51	08	49	11	50	08	52	10	49	08	.08
Lay plate on yoke...	53	03	00	03	66	03	55	03	52	03	54	03	52	03	53	03	53	01	52	03	.03
Pick up cope bring to flask—blow out spr.	59	06	06	06	71	05	61	06	57	05	59	05	57	05	59	06	59	06	57	05	.05
Close mold.....	63	04	70	04	76	05	65	04	62	05	63	04	63	06	64	05	64	05	63	06	.05
Open flask.....	68	05	75	05	81	05	70	05	66	04	69	05	67	04	69	05	69	05	68	05	.05
Set flask on floor....	71	03	78	03	84	03	73	03	69	03	73	04	70	03	72	03	73	04	71	03	.03
Round off edges of mold.....	74	03	81	03	88	04	78	05	73	04	76	03	74	04	75	03	76	03	75	04	.04
Carry away (15 ft.).	82	08	91	10	97	09	86	08	81	08	84	08	82	08	84	09	84	08	84	09	.08
Return.....	89	07	97	06	3	06	93	07	87	06	90	06	87	05	90	06	90	06	90	06	.06
																					1.85

* Clean plate..... 1.25
† Drag patt. deeper & requires more sand than cope.
** Bottom board is picked up from floor
†† Cope bd is picked from table.

M 10 32 R Alum match plate. Conditions right.

FIG. 5—ANOTHER OBSERVATION SHEET COVERING A DIFFERENT JOB

that the particular job in question should take may be arrived at. The fact must again be emphasized, however, that the time set, based upon elementary time studies of this sort which were taken under proper working conditions with flasks, patterns, etc., in first class working conditions, would be absolutely useless and improper if standard conditions were not first established and maintained; therefore, it is absolutely necessary to establish such a system as has been briefly outlined for planning the work, providing all necessary equipment and materials, so that they will be on hand when wanted, before any attempt is made in the matter of time study, or the setting of tasks, or piece rates on a basis of elementary time study.

The following illustrations of time studies applying to machine shop work may help to make this point clearer. Referring to the data sheet, Fig. 3, it will be noted that the workman is allowed a certain time for putting on and tightening a bolt and clamp of a given size. If, as is the case in many shops, the workman is first forced to find the bolt required and then, if the bolt is too long he has to hunt up washers to fill in the excess length between the nut and the clamp; or if he finds that the thread has been damaged, which requires him to screw the nut down with a wrench instead of spinning it on with his fingers and using a wrench only to pull it up tight, it will be utterly impossible for him to perform this elementary operation in the time given; and this in turn will result in his failure to accomplish the entire job in the time set.

Under the old system the management felt little if any responsibility for such small matters as this, but under scientific management, instead of it being nobody's duty or anybody's duty to look after such matters it becomes the duty of certain specific people, and any failure on their part to properly perform their duties immediately becomes apparent. Under the old scheme, both in day work and piece work shops, the workman suffers constant injustice, being held responsible for producing a large day's output but receiving little help and cooperation from the management. Under scientific management the management must assume its proper share of responsibility, and must by cooperating with the workman deserve the co-operation that it expects of him. Fig. 2 shows how time studies are made. First the operation is separated into its elements, which are listed under the heading "Detail Operations". In doing this the time study man must have in mind so dividing the work up as to have the individual time for as many elements as possible, which may be useful on other work.

The time is taken with a running watch, and by subtraction, the time for each element is reached and entered under the headings "Individual Time". The sheet shown provides for 10 observations of each element, but it is customary to make a larger number.

In selecting from the observations the standard or flat time for each element it is customary to select that which occurs most frequently, or predominates. We do not take the shortest, nor yet an average. For example, for the first element:

0.04 occurs 3 times.
0.03 occurs 7 times.

If there is a lack of consistency, and wide fluctuation is shown by the times for a given element, it clearly indicates something is wrong, and this element must be carefully studied alone and the trouble cleared up.

In fixing the time for any job — after conditions have been standardized — certain additional allowances must be made for such things as fatigue, for the rest periods, for the worker to attend to his legitimate personal needs and for a certain amount of false moves which are quite inevitable with human nature. Fig. 5 shows another series of observations made on a different job, a different machine, and with a different operator. I have indicated by the same figures certain elements common to both jobs, and it is interesting to note the instances in which the time is either identically the same or

INSTRUCTION CARD FOR OPERATION. **Pattern "10X"**

SHEETS, SHEET No.		Drawing No.	Machine No. M 8 30 R	ORDER No.	
MATERIAL	CLASS No.	Pieces in Lot	Time for Lot	BONUS	

DESCRIPTION OF OPERATION.—Molder closes molds. Carries out molds. Albany sand used. Sand pile located on right of machine. Table for holding flask and cope board to left. Riddle hung on hook within convenient reach on the right. Sprue carried on Ramming Block.

1	Patt. Plate laid on Yoke while closing and carrying out molds	
2		
3	Number of patterns per flask=4	
4	Wooden snap flask. 12 x 12 — 4 — 5	
5	Cu. in. capacity 1296	
6	Weight of mold, 47 lbs.	
7	Weight rolled over by Molder, 72 lbs.	
8	Weight carried out by Molder, 51 lbs.	
9	Weight of flask only, 26 lbs.	
10	Weight of patt. plate and vibrator, 13 lbs.	
11		
12		
13	(NO PREPARATION TIME ALLOWED)	
14		
15	Separate cope and drag halves of flask	.01
16	Clamp cope half of flask (1 clamp)	.03
17	Clean platen and put cope in place (bottom up)	.03
18	Put match plate in place on cope	.03
19	Blow off pattern plate every 10 molds (per pc.)	.03
20	Clamp drag half of flask (2 clamps)	.04
21	Put drag in place on pattern plate	.05
22	Sprinkle pattern plate with parting	.04
23	Put riddle on drag	.02
24	Put 1 shovel of sand in riddle	.05
25	Riddle sand onto pattern plate	.07
26	Hang riddle on hook	.02
27	Fill drag with sand (2 shovels of sand)	.08
28	Tuck with shovel handle	.09
29	Strike off and put bottom board in place	.09
30	Roll over	.05
31	Repeat items 22 to 24 inclusive	.11
32	Riddle sand onto pattern plate	.06
33	Hang riddle on hook	.02
34	Fill cope with sand (1 shovel of sand)	.05
35	Tuck with hands	.06
36	Strike off and put cope board in place	.07
37	Swing yoke forward	.02
38	Squeeze mold 65 lbs. per sq. in.	.04
39	Swing yoke back	.02
40	Put cope board on table (start cutting sprue before	
41	cope board is actually on table)	.02
42	Cut sprue	.05
43	Blow off excess sand	.06
44	Draw cope	.04
45	Lay cope on table	.04
46	Draw pattern plate	.08
47	Lay plate on yoke	.03
48	Pick up cope—blow out sprue—bring to drag	.05
49	Close mold	.05
50	Open flask (unclamp three clamps)	.05
51	Set flask on table—cope half up	.03
52	Round off edges of mold	.04
53	Carry mold out and set on floor (15 feet)	.08
54	Return to machine	.06
		1.86
	30 per cent on handling time	.56
		2.42

Time for lot = (No. of molds x 2.42)
Time for 50 molds=121.00 or 20 tenths

WHEN WORK CANNOT BE DONE AS ORDERED GANG BOSS MUST MUST AT ONCE REPORT TO MAN WHO SIGNED THIS CARD Mon. Day Year

Signed F. R. W.

Checked

FIG. 6—INSTRUCTION CARD FOR OPERATION

differs only by one hundredth of a minute, which might be error in reading the watch.

Fig. 4 is an illustration of a time study taken not only with another operator, but in another shop, the work being done on the same type of machine as that of Fig. 2, but slightly smaller.

Referring back to the question of fatigue and allowance for other exigencies, it is customary to make continuous observations for one or more days' runs, and by analyzing and charting the results the proper allowance to be added is reached for each class of work. This will be found to vary according to whether the work is simple or complicated, the number of times a cycle of elementary operations is to be repeated, and the extent to which different muscles are used, the weights handled, etc.

Two instruction cards, Figs. 6 and 7, are shown on which an allowance of 20 per cent is added to the flat time; on large difficult jobs where only one or two are made it would probably be more, as on repetition work after the first few molds a man goes through the cycle of elementary operations more or less automatically; while on a complicated job which may be done only once there is a certain pause between each element, or, in other words, time to think must be allowed.

Rest periods are very important on repetition work, and it may be demonstrated that a larger day's output will be produced if the operator rests absolutely for a certain number of minutes at regular intervals than if he tries to keep going steadily all day. If proper rests periods are taken, not only will a larger output result, but the worker will not be unduly fatigued at the end of the day. The right time for the rest periods as well as the intervals between them must be determined by experiment for each class of work.

I do not mention this matter of guarding against fatigue solely from sentimental or humanitarian motives, but because it is just as necessary, if not more so, to conserve the well-being of the man who runs the machine as it is to keep up to the standard the implements and conditions upon which his production depends. The pugilist may box 40 rounds of three minutes each with the customary rest between each round, making two hours of actual activity, and come out in fairly good condition; but probably no man living could keep on boxing two hours straight away.

There must exist a feeling of perfect confidence between the time study man and the man doing the work. As a matter of fact, it is a team proposition, and the workman must, if he is to perform his part in an intelligent manner, understand the whole proposition. Everything must be open and above board. I do not approve at all of making time studies in secret, nor behind closed doors. They should be made out in the shop under working conditions. This can only give you a general idea of time study and the part it plays in scientific management, but I hope it will make clear the fact

(*Continued on page* 512.)

INSTRUCTION CARD FOR OPERATION Pattern 10 "X"

SHEETS, SHEET No.		Drawing No.	Machine No. M 8 30 R	ORDER No.	
MATERIAL	CLASS No.	Pieces in Lot	Time for Lot	BONUS	

DESCRIPTION OF OPERATION—OPERATIONS PERFORMED BY MOLDER.
Supplies sand. Cuts over sand. Sets cores. Closes molds. Carries out molds. Pours molds.

Item	DETAILED INSTRUCTIONS			Element Time per piece	Time for Entire Lot	Continuous or running Time
1	Molder cuts over sa. in own time. Riddle on h'k over y'k					
2	(inconv., long reach), parting on bench to left. Peaner					
3	cope board & flask on bench to left. Bottom bds. ave					
4	4½ ft. away. Carry out 15 ft. Core sd. 5 ft. from mach					
5	Support on yoke for plate. Support on platen to assist					
6	in rolling over					
7						
8						
9	Piece mounted on steel plate					
10	Number of patterns per flask=8					
11	Wood snap flask. 14½ x 10½ — 3½ — 3					
12	Weight of mold 54 lbs.					
13	Weights rolled over by molder:					
14	Item No. 5, sheet No. 2= 72 lbs.					
15	Item No. 16, sheet No. 2=104 lbs.					
16	Item No. 5, sheet No. 3=138 lbs.					
17	Item No. 13, sheet No. 3=92 lbs.					
18	Weight of flask, 26 lbs.					
19	Weight carried out by molder, 60 lbs.					
20	Weight of plate, 26 lbs.					
21	Weight of false plate, 20 lbs.					
22						
23						
24	(NO PREPARATION TIME ALLOWED)					
25						
26	Separate cope and drag			.01		
27	Clamp drag (1 clamp)			.03		
28	Put drag on platen			.03		
29	Put plate on drag			.03		
30	Sprinkle plate with parting			.05		
31	Put riddle on plate			.02		
32	Put handful core sand in riddle			.04		
33	Riddle			.04		
34	Put 1 shovel of sand in riddle			.05		
35	Riddle			.07		
36	Hang riddle on hook (on wall over yoke)			.01		
37	Tuck with hands			.08		
38	Strike off (must be done carefully)			.16		
39	Blow off and clean plate thoroughly			.15		
40	Put false plate in place			.07		
41	Clamp cope (1 clamp) includes moving to bench			.05		
42	Put cope on drag			.05		
43	Roll over, empty flask except for cheek			.04		
44	Sprinkle with parting			.04		
45	Put riddle on flask			.02		
46	Put 1 shovel sand in riddle			.05		
47	Riddle			.05		
48	Hang riddle on hook			.01		
49	Tuck with hands			.06		
50	Fill drag with sand (1 shovel)			.07		
51	Pean with Peaner			.16		
52	*Strike off and put bottom board in place			.14		
53	Rap board in place with peaner			.06		
54	Roll over			.08		
55	Sprinkle with parting			.05		
56	Put riddle on cope			.02		
57	Put 1 shovel sand in riddle			.05		
58	Riddle			.05		
59	Hang riddle on hook			.01		
60	Tuck with hands			.08		
61	Fill with sand (1 shovel)			.07		
62	Pean with peaner			.16		
63	Strike off, put cope board in place (carried on bh.)			.11		
64	Swing yoke forward			.02		
65	Push flask back			.02		
66	Squeeze			.05		
67	Swing yoke back			.01		
68	Remove cope board			.04		
69	Cut sprue (Cutter on yoke)			.05		
70	Blow off			.06		
71	Rap			.06		
72	Draw cope			.10		
73	Put cope on bench			.04		
74	Blow off plate			.05		
75	Draw false plate, put on floor			.04		
76	Sprinkle cheek with graphite			.11		
77	Blow off			.06		
78	Bring drag to cope			.04		
79	Close			.08		
80	Put cope board in place			.04		
81	Roll over			.07		
82	Draw drag			.04		
83	Put on bench			.04		
84	Draw plate			.06		
85	Put plate on yoke			.02		
86	Repair mold, per pc			.02		
87	Bring drag to cope			.04		
88	Close mold			.03		
89	Roll over			.07		
90	Remove cope board, put on bench			.03		
91	Unclamp flask			.02		
92	Remove flask, put on bench			.06		
93	Slick up mold			.12		
94	Carry out mold			.07		
95	Put on floor			.03		
96	Return to machine			.05		
97	Clean up round machine, time per mold			.02		
98	Clean plate, every 20 molds, time per mold			.02		
99	Clean pins, every 20 molds, time per mold			.01		
				4.03		
	20 per cent. handling time			.81		
				4.84		

* Includes picking up bottom board from pile 5 feet away.

WHEN WORK CANNOT BE DONE AS ORDERED GANG BOSS MUST AT ONCE REPORT TO TO MAN WHO SIGNED THIS CARD

Mon. Day Year

Signed F. R. W.

Checked

FIG. 7—INSTRUCTION CARD FOR OPERATION ON A DIFFERENT PATTERN THAN THAT IN FIG. 6

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A monthly journal devoted to all branches of the foundry trade

Published by

The Penton Publishing Co.

Penton Building, CLEVELAND

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Trade Outlook

FOUNDRY operations in all branches of the industry are being carried on under high pressure, the avalanche of orders being greatly in excess of producing capacity. Probably never before in the history of the casting trade has there been a return of prosperity paralleling the meteoric change of the last six months, and the most gratifying feature of the situation is the fact that there is every indication of a continuation of the present activity at least through the first six months of next year. Improved operations at shops specializing in light hardware is probably the best barometer of trade conditions throughout the country and stove foundries, which have run light for several years are busy on fill-in orders for the depleted floors of the jobbers and retailers. Builders' hardware is not moving as fast as might be desired, nor has the year been a particularly satisfactory one for the building trades. As a result, plants specializing in builders' hardware are not operating at capacity for next season's demands, the large stocks in jobbers' hands having materially curtailed orders for forward delivery. Implement foundries likewise are feeling the effect of reduced exports, shipments to Russia, Austria-Hungary and Germany, having been cut off for practically a year. On the other hand, the activity of the steel industry and the buying of the railroads has more than replaced, in tonnage at least, the curtailed demands of the other lines previously mentioned. With mills and furnaces operating at capacity, repairs are extensive and jobbing shops are unable to make deliveries as promptly as desired. Casting requirements for the automobile and motor truck industry will establish a new record for the 1916 season and all plants engaged in making cast parts for these vehicles are crowded to capacity. Malleable and steel foundries report big melts and orders are being booked to cover needs well through next year. The most disturbing feature of the situation is the advancing cost of raw materials, particularly metals. Pig iron quotations are being marked up rapidly and the non-ferrous metals are seeking new high levels. The scarcity of aluminum is becoming acute and a large amount of resale metal is changing hands. Aluminum scrap is being employed extensively and the foundrymen, not familiar with melting this material are experiencing more than ordinary difficulties. Zinc and copper prices also are moving upward, but in spite of these increased values, the demand shows no tendency to diminish. In the leading producing and consuming centers, foundry grades of pig iron are quoted as follows: No. 2, local, Chicago, $18; Cleveland, $17.30; Pittsburgh, $16.95 to $17.45; Buffalo, $17; Philadelphia, $17.50 to $17.75; Birmingham, $13.50 to $14, and southern Ohio, Ironton, $16.50. Malleable iron is quoted at $17.50, Chicago; $18.25 to $18.50, Philadelphia, and $17.50 to $18, Buffalo. Charcoal iron also has been advanced and is held at $18.25 to $18.75, Chicago, and $19 to $20, Buffalo. Non-ferrous metal quotations follow: Casting copper, 20c, New York; zinc, 18½c to 19c, St. Louis; tin, 39c to 40c; aluminum, 58c to 59c, and antimony, 39.50c to 40c.

New Equipment for Foundry and Pattern Shop

Steam-Driven Air Compressor—Motor-Driven Rotary Sand Riddle—Combination Jolt and Squeeze Ramming, Split Pattern Machine—Rotary Table Sand-Blast—Multiple Molding Machine

A STEAM-DRIVEN air compressor, which is designed to operate satisfactorily under high pressures and superheat, as well as at more moderate pressures, has been brought out by the Ingersoll-Rand Co., New York. This machine is equipped with a balanced piston steam valve and valve gear. The new type of compressor is shown in Fig. 2.

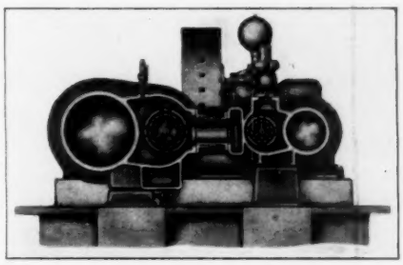


FIG. 1—SECTION SHOWING CYLINDER VALVES AND STEAM RECEIVER

Through the use of a balanced valve, it is possible to control this machine by automatically varying the point of cut-off in the steam cylinders. This method of regulation maintains a constant speed for changing steam pressure and at the same time varies the speed of operation to the demand for air. The steam is always admitted to the steam cylinder at full boiler pressure and the compressor therefore operates automatically at its highest efficiency. The automatic cut-off regulation is claimed to result in a considerable saving in actual steam consumption.

The piston valve is a balanced valve of the telescopic type. The cut-off valves are right and left hand threaded to a cut-off valve stem. The steam is admitted through the center of the valve, passing then through the various ports to the cylinder and being exhausted by the ends of the valve. This construction exposes the valve chest covers and steam packings to exhaust pressure only and reduces the liability of leakage. The design of this valve is claimed to preclude any possibility of warping. The valve is said to be so balanced that the friction is minimized and lubrication facilitated.

The steam ports are large and unusually direct. A special effort was made to reduce the condensation surfaces in the cylinders. Steam economy is said to be promoted by the complete insulation, the separation of live and exhaust steam passages, and by the fact that the steam chest partially encircles the cylinder. This arrangement is shown clearly in Fig. 3.

The steam receiver is a direct connection between the high and low pressure steam chests. The low pressure chest is proportioned to furnish additional capacity. Its location permits the heat to be used in heating the cylinder and valve instead of being lost by radiation. Cylinder alignment is maintained by a special expansion joint. The governor is a speed and pressure regulator which varies the cut-off by automatically rotating the cut-off valve stem and

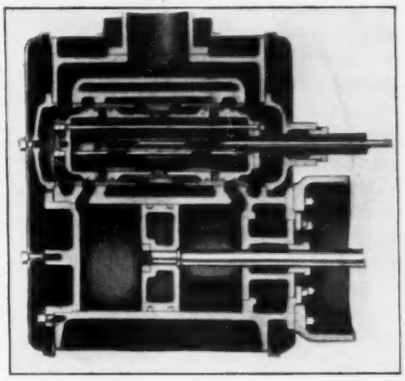


FIG. 3 — SECTION THROUGH HIGH PRESSURE STEAM CYLINDER

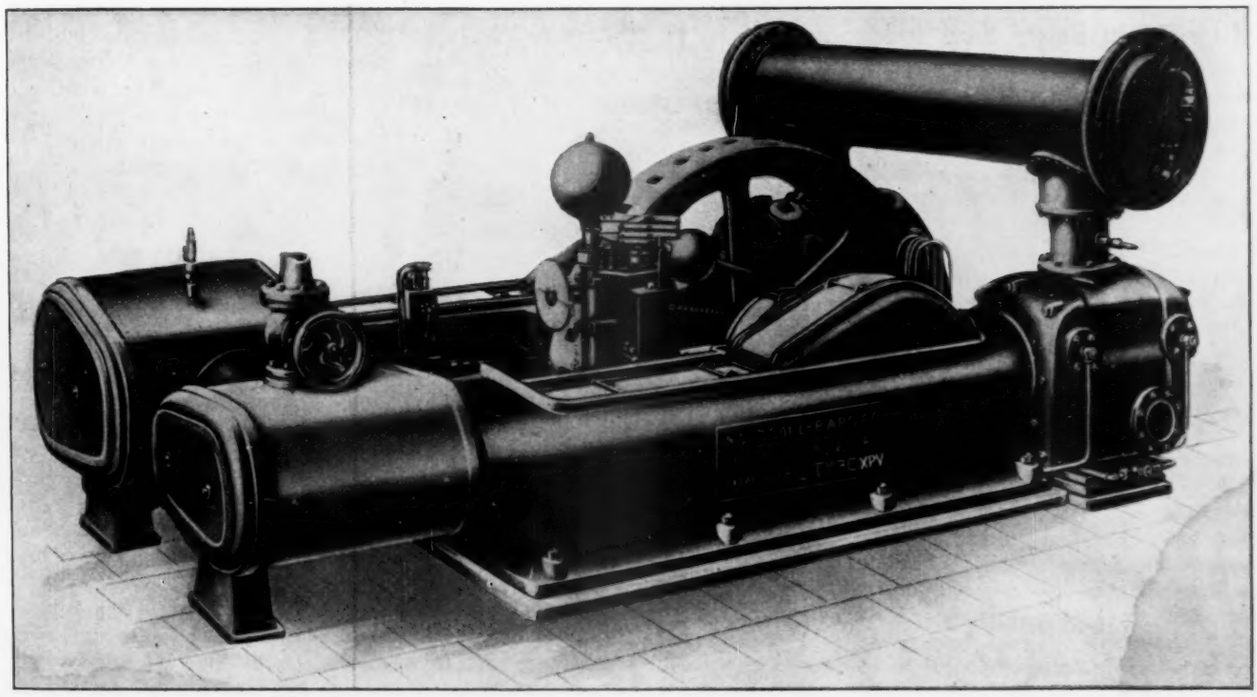
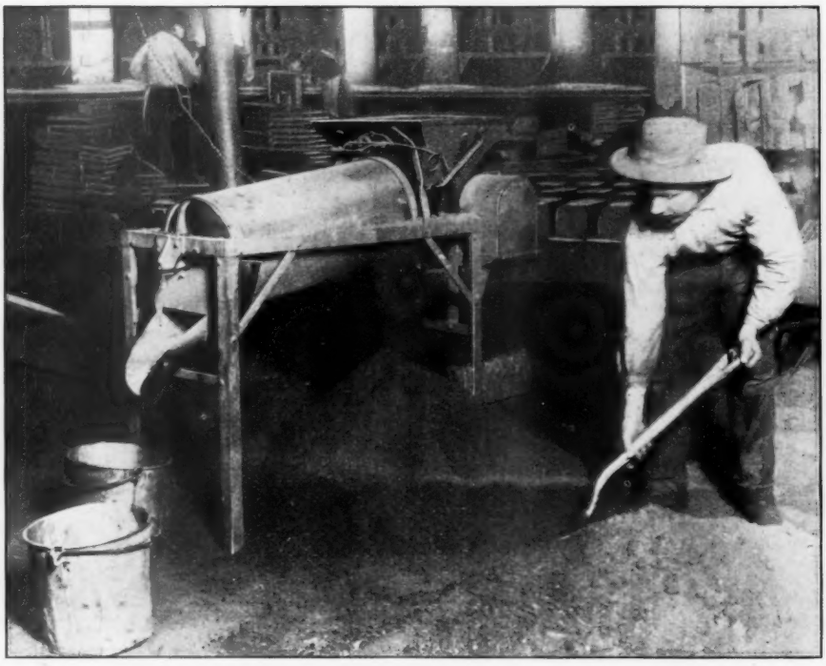


FIG. 2—STEAM-DRIVEN AIR COMPRESSOR EQUIPPED WITH BALANCED VALVE

changing the relative position of the cut-off valves. Essentially it is a chain-driven, rotary oil pump, acting against a weighted plunger. The variation in oil pressure, due to the changing speed of the compressor, or in the air pressure through the movement of the plunger, changes the cut-off point in the steam cylinders. This governor is claimed to be entirely automatic in operation. Lubrication of both air and steam cylinders and valves is secured through force feed oilers. The other features of this compressor resemble those of a similar type now in service. These include completely enclosed main frames containing the reciprocating parts, automatic lubrication by the bath system and water jacketed air compressing cylinders. The new compressor is built in capacities from 608 to 3,620 cubic feet per minute and for discharge air pressures from 10 to 110 pounds per square inch.

Motor-Driven Rotary Sand Riddle

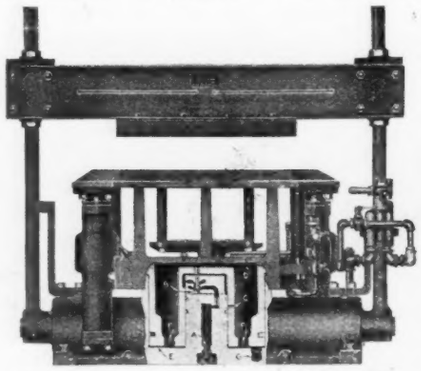
A motor-driven rotary sand riddle, adapted to screening molding and core sand, built by the Hall-Holmes Mfg. Co., Jackson, Mich., is shown in the accompanying illustration. The riddle is portable, being equipped with two truck wheels at one end, but in the accompanying illustration these wheels are covered by the sand heap. The handles attached to the front supports, facilitate lifting the riddle to move it to any desired part of the shop on the two truck wheels. The frame is so constructed that a wheelbarrow readily can be set underneath the screen. The rear legs are adjustable and can be raised or lowered to give any incline to the screen desired. This is advantageous in screening core sand that has just been mixed with oil and permits of raising the frame so that the screen is nearly level and the lumps of sand and oil will separate and will pass through the screen before rolling out of the front end. A tapping device keeps the screen clean and open even when using wet



MOTOR-DRIVEN ROTARY SAND RIDDLE BUILT BY THE HALL-HOLMES MFG. CO.

material. This device can be adjusted to strike a light, medium or heavy blow, or can be thrown out of operation entirely if so desired. The screen can be changed quickly from one mesh to another by removing two bolts in the friction band which holds the screen to the drum and by putting on a screen of different mesh. However, in shops requiring screens for two or three different classes of work and in which the screen is frequently changed, the mixer is furnished with extra drums. Changing the drum is an exceedingly simple operation. The head is removed by loosening two thumb nuts and this permits of slipping off the drum and placing another in position. It is claimed that the entire change can be effected in less than two minutes. The hopper and discharge chute is made of heavy gage steel. In the hopper is located an agitator which revolves when the screen is in operation to prevent the sand from clogging. This rotary riddle is furnished either with a crank for hand power and pulley for belt power, or can be driven by an electric motor. When electrically operated, it is driven by a ¼ - horsepower motor, either alternating or direct current. The motor is connected to the screen by a worm gear, which operates in oil, the motor being entirely enclosed to protect it from sand and dust. The control switch is mounted on the motor housing within easy reach of the operator. The current from a lighting circuit furnishes sufficient power to drive the motor.

The riddle shown in the accompanying illustration is installed in the plant of the Lusk Foundry Co., Jackson, Mich.



COMBINATION JOLT AND SQUEEZE RAMMING, SPLIT PATTERN MACHINE

Jolt Ramming Device on Plain Split Pattern Machine

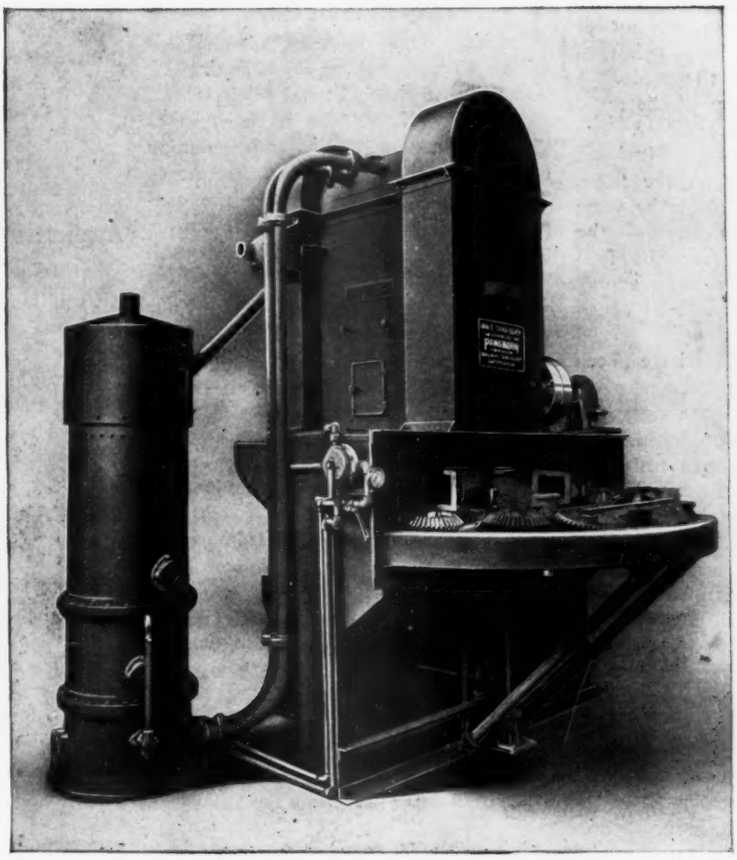
The E. H. Mumford Co., Elizabeth, N. J., molding machine manufacturer, has brought out recently the combination jolt and squeeze ramming, split pattern machine shown in the accompanying illustration. The addition of the jolt-ramming feature to the plain split pattern machine is said to eliminate hand tucking, and to avoid the difficulties experienced with molds which are unevenly rammed or which are poorly vented.

The mold is rammed entirely by power, as in a plain jolt-rammer. Each mold is given a certain number of jolts, squeezed, and the pattern is then drawn by machine, so that all molds are rammed to the same density. Difficult work, it is said, may be both stooled and stripped on this machine.

In substantiation of the claim that this machine increases the output, the result of operating it on brass valve work is given. This work required a 12 x 16-inch flask, 4 inches deep in each half. A saving of 20 seconds per half is said to have been effected by the addition of the jolt-ramming device to an old split pattern

machine. The saving, therefore, on this light class of work, amounted to 40 seconds per mold. On deeper and larger work, the saving is said to be increased. The new machine is now being used in making locomotive lubricators and injectors, flanged fittings, valves, motorcycle crank cases, etc.

The machine is of simple design. The valve used is the single-piece type employed by the Mumford company for many years in its plain jolt-rammers. The small internal cylinder for jolting is said to be very economical in the use of air. Counterbalanced springs are enclosed in the base. The company's type of hand start double guide cylinder pattern lift, and vibrator frame, are used.



DIRECT HIGH PRESSURE ROTARY TABLE SAND-BLAST

Rotary Table Sand-Blast

The direct high pressure rotary table sand-blast shown in the accompanying illustration is a recent development of the Pangborn Corp., Hagerstown, Md. It is designed for handling medium and small castings. These machines are built in two sizes, having 90-inch and 70-inch diameter tables respectively. The over all height of the large machine is 12 feet and of the small machine, 9 feet 6 inches. Both sizes have the same clearance over the surface of the table.

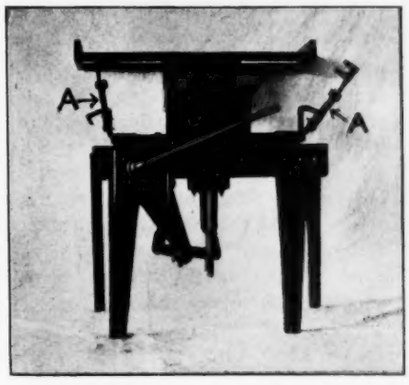


FIG. 1—KIMBALL MOLDING MACHINE

These machines comprise a multiple chamber pressure sand-blast, complete rotary table with driving mechanism and housing, and a belt bucket elevator. The equipment is centrally controlled and operated from in front. The table makes one complete revolution in five minutes. The blasting compartment is completely enclosed by a series of rubber curtains, so that no sand or dust comes outside the housing. The rotating nozzles are set at a slight angle and pass over the entire surface of the table. Two nozzles are provided on the large and one on the small machine. All moving parts are enclosed.

In operation, the workman places a layer of the pieces on the table as it rotates. The nozzles revolve inside the housing and cover the entire surface of the table. As the pieces come out from under the curtains they are turned over. When thoroughly sand blasted, they are removed and new work is placed on the table. The sand, after striking the work, falls through the grates of the table to the boot of the elevator and is returned automatically to the sand-blast. The refuse is thoroughly separated from the sand. The multiple chamber sand-blast refills without interrupting the blasting. The dust laden air is exhausted through the openings at the rear of the housing. The rotating of the table and the handling of the sand require approximately four horsepower. Sand, chilled iron grit, shot or any other abrasive can be used.

New Multiple Molding Machine

H. E. Kimball, foreman of the Dallas, Tex., foundry of the Continental Gin Co., has designed a new type of multiple molding machine. The machine, which has been used on a large number of jobs at this plant, is shown in the accompanying illustrations. A description of the practice in molding water meter boxes furnishes a clear outline of the operation of the Kimball machine. The flask used for this work is 12 x 15 x 3½ inches. It is made of 5/16-inch cast iron and has lugs with pin holes for a ⅜-inch pin at each end. The patterns are attached to a wooden follow board, 12 x 20 inches, which has pins matching the flask. A gate is attached to the board to connect all of the patterns and a turned gate pin or stick, 2½ inches long, is nailed in the center of the gate. The flask is placed on the board and rammed in the same manner as a snap flask. It is struck off with a straight edge and about ⅛-inch of sand is then riddled on to it. A 4-inch wooden rolling pin is used for rolling the sand. A roll-over board then is placed on top of the pattern, which is rolled-over on the machine.

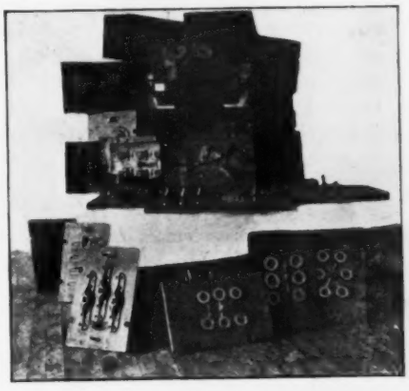


FIG. 2—TYPES OF PATTERNS USED

The machine, which operates somewhat similar to a stripping plate machine, then draws the patterns, with follow board, out of the drag. In-

stead of letting the patterns down through the plate, the machine moves upward, lifting the follow board, with the pattern, clear from the mold. A gate is cut to the bottom of the mold with a brass tube or gate cutter. The mold then is ready to be lifted off and placed on a board on the floor. The next mold is finished in the same manner and placed on top of the first, forming the cope for the first mold and the drag for the second. This operation is repeated seven times.

Then, after the molds have been stacked as high as desired, a plain cope is rammed and a gate or sprue is cut through to the top mold. All the molds are then clamped together. In pouring, one end of the ladle shank rests in a fork placed high enough to reach the top of the mold. The iron is poured in a small stream. Two adjustable arms are provided on the top of the machine, as shown at *A* in Fig. 1. These arms swing out to permit the removal of the mold and swing into a position under the ends of the follow board in order to raise the board in drawing. The machine can be adjusted for any ordinary pattern in the same manner as a stripping plate machine. In Fig. 2 are shown patterns and follow boards used in the Continental Gin foundry.

Method for Controlling Chill in Cast Iron

(*Continued from page* 493.)

fact, a close analysis of Mr. Johnson's data brings out more forcibly my contention, namely, that the quantitative control of chill in commercial cast irons, aside from the physical effects of casting temperature, size of test, and size of chiller, is practically dependent upon the percentages of silicon and total carbon present. In support of this statement, a chart, Fig. 8, is offered, in which Mr. Johnson's data are tabulated. His *A* and *B* series, not having a measurable chill, have been left out. It will be noticed that his *G*, *C* and *F* series, forming a line for ⅛-inch chill, and his *E* on a line representing ¼-inch chill, are in perfect agreement with my data, shown in the lower right-hand corner and all lines verge toward the point representing 6.67 carbon and no silicon. While his speciman *D* does not seem to agree with this theory, it is entirely possible that it may not be in its proper position, either because of error in analysis, making silicon or carbon too low, or because the sample was not representative; though a larger test pig than usual, or very low pouring temperature, would cause the specimen to show no chill.

Safety in the Foundry

"Safety in the Foundry," is the title of a 188-page volume by Magnus W. Alexander, of the General Electric Co., Schenectady, N. Y., who is chairman of the committee on safety and sanitation of the National Founders' Association. The book is published under the auspices of this organization and can be purchased by those not affiliated with this society at a price of $1.50.

This book has grown out of the investigations carried on during the past two years by the author in his capacity as chairman of the National Founders' committee on safety and sanitation and while considerable of the information was published by the committee in the form of bulletins, the book contains this material in a revised form, brought up-to-date and enriched by illustrations not published heretofore. Many new features have been incorporated and entirely new chapters have been added. A chapter on physical examination of employes has been appended because of the conviction that the physical fitness of an employe for his work, equally with the safe condition of work rooms and work tools, is an essential element in the safety and well-being of the employe.

The strongest appeal for recognition that can be made by this work is the fact that it reflects the experience and expert judgment of many practical foundrymen and foundry executives throughout the country. They have contributed many valuable suggestions and their shops have been utilized for practical experiments with safety devices, the effectiveness and desirability of which were to be proved before they could be recommended for adoption. The bulletins, as originally issued by the National Founders' Association, attracted wide attention and the suggestions and recommendations contained therein have been followed in many shops with the result that working conditions today are more satisfactory from the standpoint of the employe than heretofore. No undertaking in recent years by any association has been directed toward a more humanitarian goal than this and the work throughout reflects the painstaking effort of the author and his coworkers. The volume will prove to be a valuable addition to every foundryman's library as every phase of safety work pertaining to foundry operations is covered in detail.

A booklet entitled "Helpful Hints on Air Compressor Installations" has been issued by the Gardner Governor Co., Quincy, Ill. The various points considered are selection, location, air tanks, leaks, safety valve, lubrication, air pressure, speed, heat, cooling water, thermo-syphon water, suction pipe, strainer, discharge pipe, check valve, belt drive, unloader, air lift, noise and repairs. Illustrations of various types of air compressors built by this company also are included.

Application of Scientific Management

(*Continued from page* 507.)

that it is not a thing to be taken up without a full understanding of what it involves.

It would seem that there is no more fertile field nor any industry requiring scientific management more than the foundry. Great progress has been made in the metallurgical branch of foundry practice, but much of its benefit is lost due to the lack of a proper system and organization in the foundry for putting into practice the results of the metallurgist's work. I have in mind a foundry which made several classes of work calling for totally different mixtures, a part of its work being machinery castings which were to be soft, and another part being castings which were to be hard, and in spite of the maintenance of a metallurgical laboratory, there were all too frequent instances of the castings which should have been hard being soft and those which should have been soft being hard. As far as could be determined, this resulted from insufficient control or the lack of adequate system and supervision in the charging of the cupolas, the pouring, and in segregating the different grades of scrap.

Another case which came to my attention was that of a concern which had been having trouble with its castings and employed a metallurgist to work out an analysis and formula to serve as a guide for the foundrymen in melting, but still its castings continued to be hard or defective. The manager of the concern sent for the foundryman and questioned him as to whether or not he was making proper use of the information supplied by the metallurgist, and received the following reply: "Mr. Jones, I can't understand why that iron doesn't come right because I have put a piece of paper containing the analysis into the cupola with every charge."

The Cleveland Galvanizing Works Co., Cleveland, has purchased 19 parcels of land adjoining its plant, which will permit of making large extensions in the near future. The company manufactures a line of weldless wire chain, cash chain, etc. The property has a Pennsylvania railroad siding and fronts on four streets.

1916 Meeting of Foundrymen

Cleveland has been selected for the 1916 meetings of the American Foundrymen's Association and the American Institute of Metals, which will be held at that place during the week of Sept. 11. The exhibition of foundry supplies and equipment will be conducted in the Coliseum, which contains 60,000 square feet of floor space on one level. The location of the exhibition hall is within close proximity to the leading hotels, which will make it of ready access to those attending the sessions of the two technical societies. Headquarters have not yet been established, but announcement of this will be made in the near future. This is the second time in the history of the American Foundrymen's Association that Cleveland has been chosen, the previous meeting having been held in that city in 1906, when the first exhibition was conducted in the Central Armory. Since that date the exhibition feature has grown tremendously and this likewise has been accompanied by a large increase in the membership of the two allied societies.

Casting Steel Chills in Bronze Castings

By W. J. Keep

Question:—We are experiencing difficulty with casting steel chills in bronze. Will you kindly advise us how this can best be done to insure proper results? For instance, how warm should the chills be and would something in the nature of a flour dip before the chills are placed cause the metal to lay closer and avoid steaming the mold?

Answer:—It probably will be advisable for you to coat the chills with tin. You might warm the chills and dip them in a 25 per cent solution of silicate of soda and water and when dry the chills will not rust. It probably will not be necessary to warm the chills unless they are so large that they will chill the bronze, in which case it might be necessary to heat them.

New Stow Grinder

An adjustable, flexible grinder, built by the Stow Mfg. Co., Binghamton, N. Y., is described in a four-page folder recently issued. This grinder is particularly adapted for installation in metal-working establishments and can be used to advantage in steel and iron foundries. The motor shaft combination is mounted on a truck which can be transported to any part of the shop, thereby eliminating the necessity of taking the work to the tool. The motor is enclosed with the starting equipment incorporated within the motor frame. In the direct current equipment the variation in speed is obtained by means of a plunger in the pole piece which operates to change the resistance of the magnetic circuit. It is claimed that no power is lost in this operation. This speed variation permits of the consumption of worn emery wheels down to the minimum, insuring the proper cutting speed regardless of size. The motor is so balanced on the truck that it may be adjusted to the proper angle to meet all grinding conditions. This grinder is also furnished for alternating current, but the motor does not regulate any cycle or phase.

The Carborundum Co., Niagara Falls, N. Y., manufacturer of abrasive materials, is erecting a 2-story, 80 x 144-foot kiln building at that place. The company advises that the equipment contracts have been placed.

Trade Notes

The Buffalo Foundry & Machine Co., Buffalo, manufacturer of vacuum and chemical apparatus, has opened an office at 1432 Whitehall building, New New York City. The company also does a general jobbing, foundry and machine business.

"A Brief Description of a Powerful Core Binder," is the title of a 16-page booklet issued by the Robeson Process Co., New York City, which is devoted to the use of glutrin in core mixtures. The many advantages of this material are pointed out and views of a few of the many different types of cores, both small and large, that can be made by this binder also are included.

The Coleman Foundry Equipment Co., Cleveland, industrial plant and foundry engineer, will design and superintend the construction of a machine shop for the American Car & Ship Hardware Mfg. Co., New Castle, Pa. The building will be 60 x 140 feet. The office will be located on the second floor of this structure and will be 30 x 60 feet.

The United Smelting & Aluminum Co., New Haven, Conn., has completed its new plant for the manufacture of aluminum ingots, alloys, etc. It is equipped with 17 modern melting furnaces and the necessary auxiliary equipment for economically handling materials.

Last month, the Snyder Electric Furnace Co., Chicago, started up three basic furnaces at the plants of the Gerlinger Steel Casting Co., Milwaukee; Halcomb Steel Co., Syracuse, N. Y., and Dayton Steel Foundry Co., Dayton, O. The Gerlinger furnace has a 24-hour capacity of six tons. The Halcomb furnace is of 30-ton and the Dayton furnace of 10-ton capacity.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The American Malleable Co., Owosso, Mich., will add another furnace and double its capacity.

The Love Machinery Co., Lexington, Ky., will establish a foundry for the manufacture of lathe castings.

Percy and Frank McCallum, Chatham, Ont., Can., will establish a brass and iron foundry at Bathurst, N. B.

The Federal Brass Works, Detroit, has taken over the plant of the Brass & Aluminum Foundry & Machine Co.

The Beloit Foundry Co., Beloit, Wis., contemplates leasing a plant in South Beloit and will double its capacity upon removal to the new quarters.

C. S. Rinebolt, Lima, O., formerly with the Crucible Casting Co., of that city, will establish a brass and aluminum foundry.

The J. R. Fleming & Son Co., Scranton, Pa., has been incorporated with $50,000 capital stock by J. R. Fleming, J. T. Fleming and S. A. Fleming.

The Fay Foundry Co., St. Joseph, Mich., has been reorganized as the Fay-Kultgen Foundry Co. with $12,000 capital stock by M. Fay, John Kultgen and Matilda B. Fay.

The Shortell Iron Foundry Co., Seymour, Ct., has been incorporated with a capital stock of $50,000 by William H. Shortell, Frederick Shortell and Robert Shortell.

The foundry buildings of the defunct A. & H. Foundry Co., Hamburg, Pa., have been sold to M. A. Dunlap, Pottsville, Pa., who is expected to put the plant in operation.

The Metal Specialties Mfg. Co., Wilmington, Del., has been organized with $250,000 capital stock by Herbert E. Latter, C. L. Rimlinger and Clement M. Egner. Castings, mercantile devices, machines, etc., will be manufactured.

The Sanitary Mfg. Co., Kenova, W. Va.,

has been organized with a capital stock of $300,000 to engage in the manufacture of sanitary fixtures. A plant will be equipped which will include a brass foundry, machine shop, enameling department, etc.

The Specialty Machine Co., Toronto, Ont., Can., has been incorporated with a capital stock of $150,000 to engage in a foundry and mechanical engineering business. The incorporators are George M. Willoughby, James H. Fraser and Francis H. Hurley.

The Canadian Chadwick Metal Co., Ltd., Dundas, Ont., Can., has been incorporated with $40,000 capital stock to engage in a foundry, machine and engineering business. John R. Marshall, Arthur B. Turner and Henry A. Burbridge are the incorporators.

The Neely Rotary Engine Co. of Canada, Ltd., Toronto, Ont., has been incorporated with a capital stock of $200,000 to engage in the manufacture of engines, automobiles, motors, machine castings, tools, etc. The incorporators are Wilbur F. Neely, Arthur T. Lawson and John Whitfield, 33 Sherbourne street, Toronto.

New Construction

The Franklin Foundry Co., Franklin, Pa., will erect a plant.

The Louis Sacks Iron Foundry, Newark, N. J., will build a one-story foundry.

The Dudlo Mfg. Co., Fort Wayne, Ind., will erect a foundry at a cost of $5,000.

The Doehler Die Castings Co., Toledo, O., will erect a new plant on Smead avenue.

The Davis Foundry Co., Hornell, N. Y., will erect a two-story addition, 40 x 100 feet.

The Crown Cork & Seal Co., Baltimore, contemplates building a foundry.

The Pequonnock Foundry, Bridgeport, Conn., will erect an addition, 48 x 75 feet.

The Buick Motor Co., Flint, Mich., will build a 2-story foundry, 300 x 530 feet.

The Clinton Cam Co., Clinton, S. C., contemplates erecting a foundry.

The Crucible Casting Co., Lima, O., is erecting an addition to its plant.

The Wet Wash Laundry, Omaha, Neb., is building a 2-story foundry, 48 x 150 feet.

The Canadian Hanson & Van Winkle Co., Toronto, Ont., is erecting a brass foundry to cost $5,000

The Baltimore Car & Foundry Co., Baltimore, will erect a 273 x 1,200-foot addition to its plant at a cost of approximately $500,000.

The Vitaphone Co., Plainfield, N. J., manufacturer of talking machines, etc., will build a brass foundry.

The Ornamental Foundry Co., Anniston, Ala., will build a foundry, pattern and machine shops.

The Bayonne Steel Casting Co., Bayonne, N. J., has purchased a site on which it will erect a plant.

The Smith Foundry, Salem, Mass., will build another one-story brick building, 30 x 50 feet.

The American Abrasive Co., Irvington, N. J., is erecting a foundry at a cost of $10,000.

The Kansas City Radiator Co., Kansas City, Mo., will build a foundry, 75 x 120 feet, to cost $11,000.

The Western Gas Construction Co., Fort Wayne, is rebuilding its foundry recently damaged by fire.

The Clifton Plating & Mfg. Co., Springfield, O., will erect a 24 x 60-foot addition to its factory.

The Arcade Malleable Iron Co., Worcester, Mass., is building a concrete brick and steel addition, 70 x 122 feet.

The Ellison Brass Mfg. Co., Falconer, N. Y., recently incorporated with $60,000 capital stock by R. D. Ellison, O. F. Ellison Jr. and J. E. Ellison, contemplates erecting a concrete brass foundry, 50 x 100 feet.

John H. Mullen, Shamokin, Pa., who recently sold his foundry, contemplates building a new foundry and machine shop.

The American Piston Ring Co., Newark, N. J., will erect a 1-story, 73 x 123-foot plant at a cost of approximately $10,000.

The Standard Crucible Steel Casting Co., Milwaukee, Wis., is building a one-story, brick and concrete addition, 40 x 40 feet.

Permit has been granted to the Morrison Foundry Co., Newark, N. J., for the erection of a one-story steel and brick shipping room.

The La Plant Co., Marshalltown, Ia., will build a brick or concrete foundry, 60 x 200 feet, for the manufacture of furnace castings.

The Ruston Foundry & Machine Shops, Alexandria, La., will rebuild its plant, including a 60 x 100-foot foundry and will install new equipment.

The A. J. Lindemann-Hoverson Co., Milwaukee, Wis., will erect a one-story brick annealing shop, 135 x 160 feet, to cost approximately $25,000.

Contract has been awarded for the erection of a two-story addition, 70 x 160 feet, for the Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.

John Rohrberg, proprietor, Camas Brass Works, Camas, Wash., contemplates extending his foundry to provide for the casting of iron as well as brass and aluminum.

Contract has been awarded for the erection of a 41 x 50-foot addition to the foundry of James M. Craig, brass founder, Hartford, Ct. Equipment will be installed shortly.

Additions costing approximately $100,000 will be erected by the Aluminum Goods Mfg. Co., Manitowoc, Wis. Plans have been prepared for a five-story steel and brick structure, 54 x 300 feet.

The Bristol Brass Co., Bristol, Ct., is erecting a $100,000 addition to its plant. The building will be of brick and steel, containing a main bay, 180 x 300 feet, with a wing, 60 x 300 feet, to be used as a casting shop.

NEW TRADE PUBLICATIONS

FIRE BRICK. — The Betson Plastic Fire Brick Co., Rome, N. Y., has issued an attractive folder devoted to its product. The booklet calls attention to the advantages of a one piece boiler furnace lining. The company's plastic fire brick consist of refractory material which forms a jointless lining around the entire furnace hearth. The compound is pounded in position with a mallet and smoothed with a trowel. The pamphlet also contains a number of testimonials from users of this plastic fire brick.

CUPOLAS.—In an exceedingly well illustrated, 32-page catalog, the Northern Engineering Works, Detroit, describes the Newton cupola, which is well known to the foundry trade. Numerous installation views are given, notably those of the United States Cast Iron Pipe & Foundry Co. and the Ford Motor Co., where four cupolas of this type are installed in each shop. Ladles of various types also are shown as well as shop trucks and cars, tumbling barrels, pneumatic foundry elevators, overhead track and trolley systems, electric hoists, cranes and other equipment. A pocket size booklet also has been issued by this company which contains installation views of the various types of cranes which it manufactures and a four-page bulletin issued by this company is devoted to its electric crane trolley.

FOUNDRY EQUIPMENT AND SUPPLIES.—An exceedingly comprehensive catalog, containing 372 pages devoted to foundry equipment and supplies, has been issued by the J. S. McCormick Co., Pittsburgh. The first section is devoted to foundry facings of all kinds, core washes, sand, core binders, brushes, etc. In the equipment section are included descriptions of pneumatic floor and bench rammers, molders benches, sand blast supplies and equipment, rosin grinders, wax taper machines, foundry riddles and sand sifters of various types, sand mixing and grinding machines, flasks, melting furnaces for brass foundrymen, magnetic separators, cinder crushers, patternmakers' equipment, sprue cutters and other machinery for the cleaning room, hoists, cranes, etc., testing machines, air compressors, molding machines, core ovens, coremaking machines, cupolas, blowers, ladles, ladle buggies, etc. The catalog is unusually complete in every detail and practically every device used in foundry operations is illustrated and described.

INDUSTRIAL CARS.—An exceedingly attractive, 152-page catalog recently has been published by the Lakewood Engineering Co., engineer and manufacturer of industrial equipment, Cleveland, describing its line of industrial cars and factory trucks. Attention is called to the fact that little consideration has been given to the proper care and construction of small steel industrial and contractors' cars and trucks. The necessity, however, of designing small light rolling stock suitable for withstanding severe usage on rough and temporary road beds, requires not only theoretical engineering ability, but practical experience and observation. Industrial cars are employed in many industries and the catalog shows a considerable number of the general types which are built. No attempt is made to enter into the details of constructing these cars, but the Lakewood company points out the necessity for each manufacturer consulting with the builder in order to determine the type of car most desirable for the service intended. The capacity of the Lakewood shops is shown by the fact that early this year an order for 30 miles of 24-inch gage portable track was shipped to France at the rate of more than one mile per day without interfering with deliveries on a large volume of domestic business. Within less than a month after the receipt of the order, the Lakewood company recently furnished eight carloads of cars and track for service in the interior of Venezuela. The catalog is profusely illustrated and handsomely printed. Among the products described are two-way dump cars, quarry cars, mine cars, skips, scale boxes, stone sleds, bin gates and cars for service in coal and ore mines, sewer tunnel work, chemical plants, steel and wire mills, cement plants, blast furnaces and automobile plants. Among the products described are side, bottom, end and all-around dump cars, rack cars, removable sides, gate dump cars, scale cars, incline cars and platform cars. The factory trucks described and illustrated include a wide variety of different styles suitable for almost any class of factory service. Other products described include tracks, clam shell buckets and concrete mixers

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